afbi AGRI-FOOD & BIOSCIENCES INSTITUTE

AgriSearch NI
Driving Excellence & Innovation

CALF REARING ESSENTIALS

AgriSearch was formed in 1997 to provide a mechanism through which, dairy, beef and sheep farmers could have a direct invlovement in near market research.
Funds contributed to agriSearch are used to commission research into the improvement and development of sheep, beef and dairy farming and to disseminate and publish the results.
Dairy projects are recommended to AgriSearch Trustees by a Dairy Adisory Committee

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Introduction

AgriSearch

With increasing pressure on dairy farmers to become more efficient whilst sustainable in production, as well as maintaining high standards of animal welfare and reducing the use of antibiotics, it has never been more important to look after the future of your dairy herd.

Youngstock, often the livestock group with the highest genetic potential on the farm, can be overlooked as they incur cost rather than delivering an income. Rearing quality heifers is essential to maintain dairy herds by replacing culled cows, however, heifer rearing represents the second biggest expense to a dairy enterprise therefore careful attention should be paid to manage it effectively. Recent economic evaluations have estimated the cost of rearing a dairy heifer to the point of calving at between £1453-£2283 (CAFRE), equating to an average of £2.31/day (Boulton et al., 2017) or approximately 6 pence per litre of milk produced.

One of the most significant factors affecting rearing costs is age at first calving (AFC), with each extra day of AFC increasing average rearing costs by £2.87. Achieving a first calving age of 24 months at the optimum weight, has beyond doubt been shown to deliver the highest level of lifetime performance. However, according to birth registration data, the average age at first calving in UK is still 28 months of age (AHDB). Achieving growth targets at key stages during the rearing process to ensure heifers are in calf by 15 months is key to delivering efficient heifer rearing.

To hit these targets, a good start in life with adequate nutrition and good health are essential. AgriSearch has co-funded several calf and heifer rearing projects in recent years. These have been conducted at AFBI Hillsborough. This booklet summarises their findings and recommendations.

AFBI

The Agri-food and Biosciences Institute (AFBI), Hillsborough have a dedicated team of heifer rearing specialists who are committed to delivering research projects investigating innovative yet practical methods which support efficient heifer rearing. AFBI's advanced facilities offer the capability to assess precise nutritional requirements enabling the development of management practices of the dairy heifer pre weaning, post weaning and during the grazing season.
Some of the AFBI heifer team research themes include:

- Understanding and enhancing the calf immune system
- Pre-wean nutrition to promote gut health and rumen development
- Early warning technologies to identify sub optimal calf health and welfare
- Energy efficiency through pre and post wean diets
- Grazing allowance and stocking rate for optimal utilization and livestock performance
- Precision feeding when housed and at grass
- Decision support tools and technologies to monitor growth and development

"Calf Rearing Essentials" encompasses guidelines to ensure the health, nutrition and environment provided on farm can support successful calf management. This booklet will outline recommendations which can be used to inform best practice and help establish clear targets for heifer rearing.

Acknowledgements

A number of agricultural representatives have contributed to the creation of this guide and AgriSearch and AFBI would like to thank the following for their input and expertise:

The importance of colostrum

Take home messages:

1. Colostrum antibodies decline rapidly after birth – it must be collected as soon as possible to ensure sufficient quality, containing at least 50g/L IgG
2. Calves need up to 4L (8.5-10%BW) of colostrum within the first 6 hours of life to establish sufficient passive transfer of immunity
3. Bacterial contamination reduces the ability of the calf to absorb antibodies therefore high hygiene standards are required during collection, storage and feeding.
4. Do not feed colostrum from Johnes positive cows and avoid the use of pooled colostrum where Johnes is present

Often referred to as "liquid gold", colostrum is the essential first feed of the calf. It is rich in antibodies, growth factors and nutritional properties needed to support the development of the calf. The calf's defence system is not fully developed at birth however antibodies transferred from the dam help deliver a level of immune protection. These antibodies (immunoglobulins) are received through the colostrum which enables the calf to develop its own immunity to combat infection. Colostrum is the first milk produced by the dam after calving. Transition milk can be collected up to the first 5 milkings post-calving, but the concentration of antibodies diminishes rapidly so it must be managed carefully to ensure maximum benefits to the calf.

The Immune System (IgG)

Maternal antibodies are not transferred to the developing calf's circulatory system during pregnancy. This means that calves are born with an underdeveloped immune system and are therefore vulnerable to disease and infections. Colostrum contains a range of immune factors (IgG, IgM, IgA) as well as antimicrobials that stimulate the calf's defence systems for survival and protect the calf for the first 6 months of life.

The main type of immunoglobulin present is IgG and the quality of colostrum is determined from the concentration of IgG detected. Insufficient consumption of the required quantity and quality of colostrum leads to a reduction in the amount of maternal IgG transferred to the calf, which results in failure of passive transfer (FPT). This means the calf does not aquire passive immunity from its dam which can increase its susceptibility to disease, risk of mortality and can ultimately impact on future productivity and profitability.

Dam Vaccination

As disease type and risk can vary widely across farms, developing health plans specific to individual farms in consultation with the vet can help to reduce the potential for calf ill-health in early life.

Producers can improve the quality of colostrum by providing strategic vaccination to the dam. When a dam is vaccinated, she will generate specific antibodies (Ab) in the mammary gland which can protect the calf through her colostrum. Pregnant dams can store these antibodies for 3-5 weeks before calving with passive transfer to the calf delivered via colostrum. Vaccination of the dam increases the supply of Ig in colostrum and can be targeted to calfhood illnesses such as scour.

Recent AFBI research indicated that vaccination of cows in the pre-calving period against E.coli, rotavirus and coronavirus had a positive impact on colostrum antibody levels which provides protection for the calf. Older animals which have been exposed to a greater number and range of pathogens often yield higher Ab concentrations in their colostrum.

It is important that the vaccination is provided at the correct dose and within an appropriate timeframe prior to calving. The need for a booster injection will depend on the age of the dam and type of vaccination, but it is vital to ensure that cows are vaccinated in advance of parturition to allow time to generate high levels of vaccine specific antibodies, otherwise the opportunity for them to be transferred to colostrum will be missed. An AFBI study found cows vaccinated against E. coli 9-12 weeks prior to calving had a 97% probability of achieving adequate levels of specific antibodies in their colostrum, wheras there was a dramatic reduction in specific antibodies if vaccinated at 0-3 weeks if vaccinated at 0-3 weeks prior to calving.

Colostrum Feeding

High quality colostrum should contain at least 50 g/L immunogloblin G (IgG) alongside adequate fat, protein, vitamins and minerals which can support calf health. Any colostrum containing <20g/L should not be used as a primary feed for newborn calves. The IgG concentration within colostrum declines rapidly after calving and AFBI research has shown a large decrease (50 %) in IgG concentration at subsequent milkings post calving (see Figure 1).

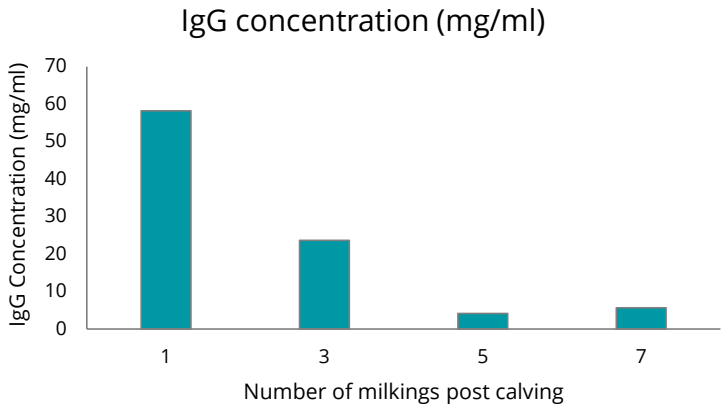


Figure 1: IgG Concentration depletes over the first 5 milkings following calving (Source: AFBI)

Therefore colostrum should be collected as soon as possible after birth, preferably within 2 hours. The ability of the calf to absorb IgG from colostrum diminishes as the gut closes during the first 24 hours of life (see Figure 2). Any colostrum / transition milk consumed 24 hours after birth will only provide local immunity to the gut and will not be absorbed by the gut. That is why it is essential to feed colostrum quickly after birth and is important to provide the first feed of colostrum ideally within the first 2 hours of birth.

Uptake of IgG by the calf is also hindered by bacterial contamination. The presence of high levels of bacteria >1,000,000 colony forming units (cfu)/ml causes a reduction in colostral pH which has a negative impact on the ability of the calf to absorb Ig. Bacterial contamination of colostrum can occur from poor colostrum handling upon collection and inadequate storage. Assessment of the total viable count (TVC) of bacterial cfu in colostrum collected on farm by AFBI indicated levels up to 14,500,000 cfu/ml (see Table 1) yet target bacterial counts stipulated for raw milk are set at <100,000 cfu/ml.

"High quality colostrum should contain at least 50 g/L immunogloblin G"

Previous research by AFBI and others has shown the storage temperature of colostrum has a dramatic effect on bacterial growth. Figure 3 illustrates the increased bacterial load (cfu/m) detected in colostrum stored at an ambient temperature of 12°C compared to 4°C and as such it is advised to keep colostrum in a refrigerator if not being fed directly to the calf. Refrigerated colostrum should be used within 24 hours of collection

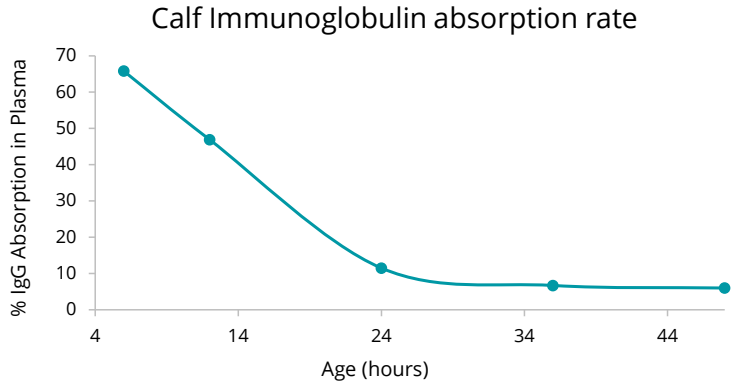


Figure 2 Ability to absorb Ig from colostrum diminishes over first 24h of life (Source: Gould)

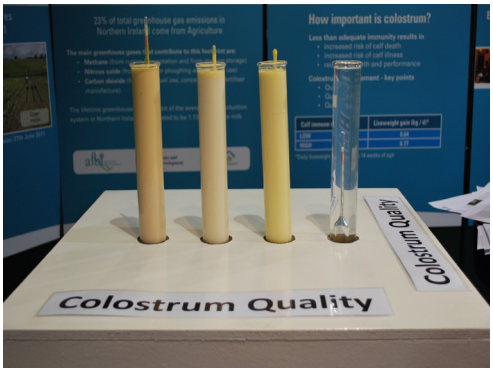
Pasteurization can be used to significantly reduce the bacterial level in colostrum but care should be taken to ensure that the IgG content and consistency of the colostrum is not negatively affected. Effective pasteurisation is at 60°C for 60 minutes and never at a temperature higher than 61.5°C. It is essential to make sure feeding equipment is cleaned thoroughly and hygiene measures are in place throughout the collection, storage and feeding of colostrum to prevent the spread of bacterial contamination.

Table 1: Nutritional composition of colostrum sampled across Northern Irish farms 2013-2015

Nutitional Quality	Average	Range
Fat (%)	6.4	3.2-16.9
Protein (%)	14.3	8.1-20.0
Lactose (%)	2.7	1.4-4.4
Total Bacterial Count (x1000 cfu/ml)	2230	127-14500
Somatic Cell Count (x1000 cfu/ml)	1609	903-2755
IgG (g/L)	55.0	27.3-128.7

Variation in Quality

Recent research at AFBI has indicated a wide variation in the quality of colostrum produced on farm. This is due to a number of management and animal factors which influence the presence of immune and nutritional properties. The volume of colostrum available from the first milking is largely dependent on the age, dry cow management, breed and parity of the dam, and generally ranges from 2-20L. Producers are often reluctant to feed heifer colostrum as they perceive it to be of inferior quality. However, as shown in Figure 4, colostrum obtained from the first lactation often contains sufficient IgG and should not be discarded – routine testing of colostrum using a colostrometer or refractometer can help to ensure that good quality colostrum is not needlessly discarded.



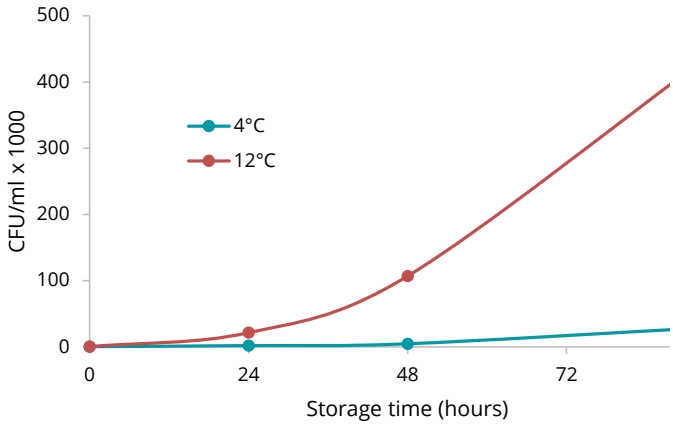


Figure 3: Bacterial load of colostrum stored at 4 or 12°C

> "Low IgG levels were associated with a dry period of less than 8 weeks and a collection time of more than 12 hours from calving"

Good quality colostrum can be stored frozen for one year at -24°C to replace poor quality colostrum. However, it is not recommended to pool colostrum since this can dilute the vital components as well as spread infection from one dam to multiple calves. Additionally, colostrum should not be fed from Johnes positive cows and pooled colostrum should not be used in herds where Johnes is prevalent.

A further study by AFBI involved a comprehensive analysis of the nutritional and immunological properties of colostrum collected across 20 commercial farms in Northern Ireland. Results from the 1239 colostrum samples collected demonstrated the variable range in the fat, protein and lactose composition) alongside the bacterial count and IgG level (Table 1).

The study revealed 44% of samples reported IgG concentration below target <50mg/ml (See Figure 5). Low IgG levels were associated with a dry period of less than 8 weeks and a collection time of more than 12 hours from calving, whilst the status of the dam (breed, parity, milk yield) and the season of calving were also shown to affect the IgG content, As such, it is important to consider the risks when developing animal management plans and training staff to ensure high quality colostrum is available to protect and support the calf's early life development.

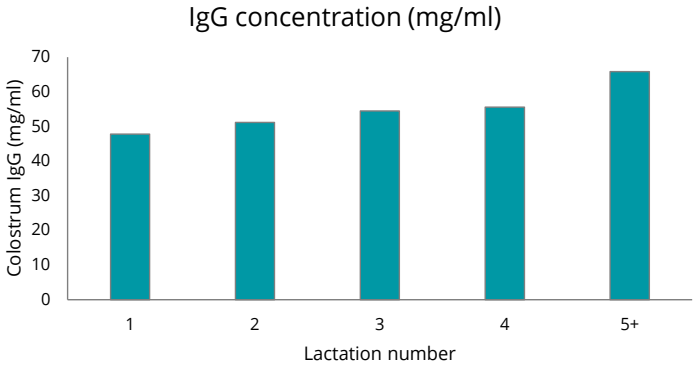


Figure 4: IgG concentration increases with increasing lactation number (Source: AFBI)

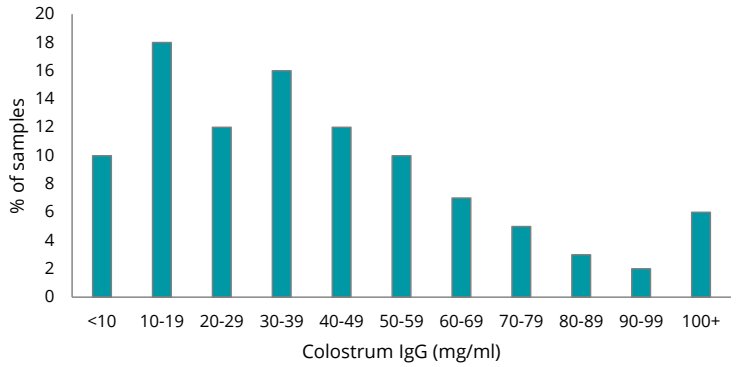


Figure 5: IgG Concentration of colostrum samples collected across NI between 2013-2015 (Source: AFBI)

Testing Quality

There are a number of rapid tests available to measure the IgG concentration and subsequently determine the quality of the colostrum on farm. The most popular methods used are the colostrometer or refractometer with devices costing around £20 (Figure 6).

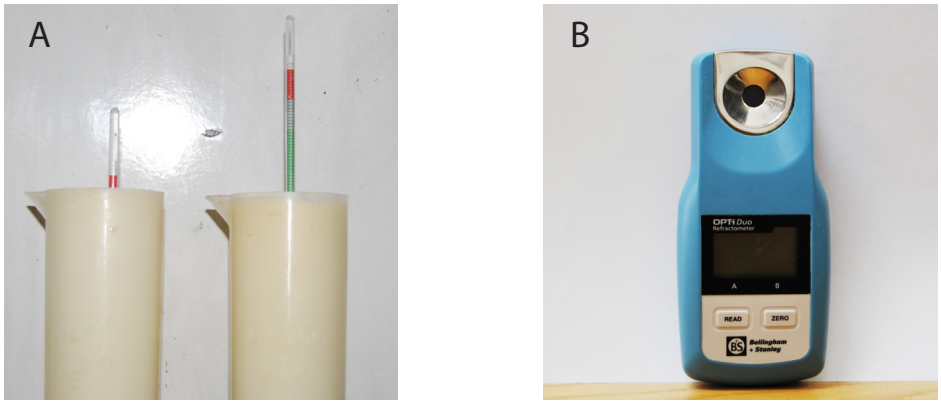


Figure 6: Rapid on site testing for IgG in colostrum by either a) colostrometer or b) refractometer

These devices are able to detect the total solids content as an estimation of the protein (IgG) represented measured against the specific gravity or % Brix respectively. A Brix reading of 22% is equivalent to 50 mg/ml immunoglobulin.

Following colostrum uptake, the amount of IgG transferred to the calf should also be checked by taking a blood sample within the first week of birth. The relative IgG concentration can be determined by the Zinc Sulphate Turbidity (ZST) test to assess successful transfer of passive immunity.

Testing conducted by AFBI and DAFM laboratories on 1199 samples from live calves less than 2 weeks of age in 2016 (Figure 7) highlighted inadequate immune status (ZST<20units) in 38% of serum samples, this indicating unsuccessful immunity transfer. Separate analysis carried out on 807 samples taken from calf carcasses during post-mortem assessment indicated that 67% of serum samples had results indicating a failure of passive transfer (All-island Animal Disease Surveillance Report, 2016).

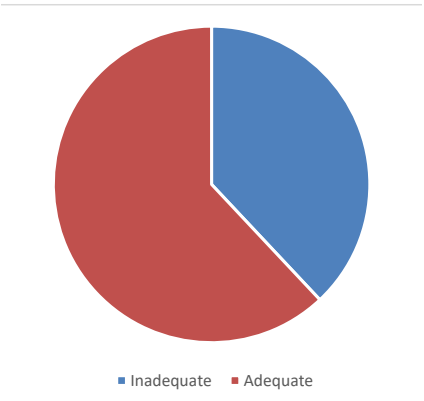


Figure 7: Results of ZST test by AFBI and DAFM laboratories of calf serum samples (n=1199)

https://www.farmantibiotics.org/wp-content/uploads/2018/01/j2247_dairy_calf_amends_sec4_testing_colostrum_aw2.pdf

Colostrum Volume

AFBI found that the quantity of colostrum consumed by the calf also affects its immune status (Figure 8). Calves fed a greater volume of colostrum at birth (equivalent to 10% birth weight e.g. 40kg calf fed 4L) achieved a higher IgG status for up to 72 hours after birth and suffered less scour than those fed 5% BW (2L) in volume of colostrum.

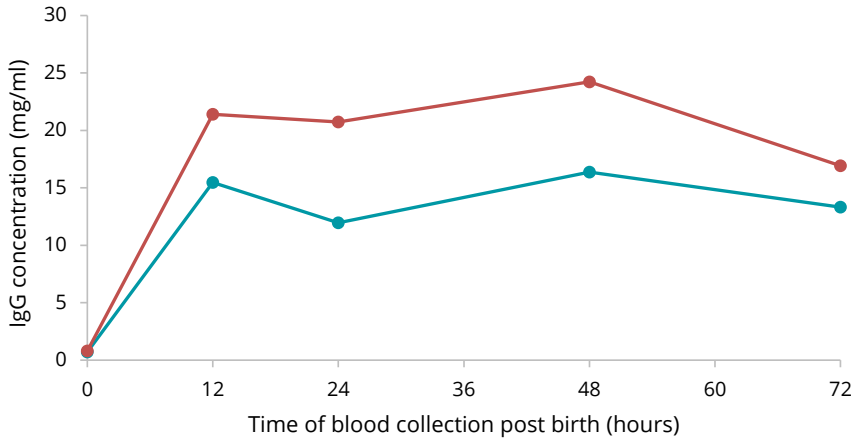


Figure 8: Variation in IgG concentration after calves fed 5% or 10% birthweight in volume of colostrum (Source: AFBI data)

It is recommended that the calf should receive 150g IgG in its first feed to establish an effective immune response. The variation in colostrum quality makes it difficult to determine the volume which can be fed to achieve this. The data in Table 2 highlights the larger volumes required depending on the concentration of IgG in low compared to high quality colostrum.

Feeding 6 litres of colostrum to a calf within the first few hours of life is not always possible yet if all calves were fed the typical 2 litres, many would never achieve sufficient antibody protection. These calves would therefore be more likely to suffer from calfhood diseases, have reduced growth rates and ultimately their performance in the dairy herd may be reduced.

Feeding a level of 10% of calf birth weight up to maximum of 4L of colostrum within the first six hours of life should ensure that the majority of calves receive the quantity of antibodies needed to give them a good start in life. There has been some concern that providing calves with 4 L colostrum at birth via stomach tube could result in overspill of milk into the rumen due to the relatively small size of the calf's abomasum. If stomach tubing calves at birth routinely, it may be advisable to provide a maximum of 3 L within two hours of birth.

Table 2: Antibody (IgG) requirements from first feed associated with colostrum quality

	Colostrum Quality		
(Required antibody intake 120g)	Low	Average	High
Antibody concentration (g/L)	20	50	97
Required amount to feed (L)	6.0	2.4	1.2

"It is recommended that the calf should receive 150g IgG in its first feed to establish an effective immune response."

Recommendations

Quickly

Collect and administer colostrum as soon as possible after birth, preferable within 2 hours of life and no later than 6 hours of life.

Quantity

Calves should be fed 3-4L colostrum at birth equivalent to 10% birth weight within their first feed

Quality

Test the colostrum prior to feeding to check antibody concentration is at least 50g/L IgG.

Hygiene

Ensure high standards of hygiene are maintained at all times through calf handling and colostrum management.

Emergency colostrum

Ensure you have a store of high quality frozen colostrum from cows within your own herd. This should be taken from cows with high health status, particularly from cows with no evidence of having Johnes Disease.

COLOSTRUM FEEDING GUIDE: Quickly - Quality - Quantity

The protocol below is an example of how to fulfil colostrum feeding requirements based on the 3Qs

1. Remove the calf from the calving environment and place in warm, dry calf pen accommodation. This should be previously disinfected and freshly bedded.
2. Dip the calf's navel with iodine to prevent infection and check after 24 hours - repeat if necessary.
3. Prior to milking, make sure your hands are clean
4. Milk the freshly calved dam to obtain sufficient quantity of colostrum. Based on 10% birth weight consumption volume, with average calf weighing 40kg, a maximum of 4.0L is needed.
5. Measure the colostrum quality using a colostrum density meter or refractometer to ensure it is of high quality (>50IgG / >22units)*
6. Feed the calf with colostrum either by a teated bottle or stomach tube within 6 hours of birth to maximise passive transfer of IgG. Some producers may prefer to split the feed, particularly if using a stomach tube, however, it is essential that the calf consumes 10% of its birth weight within the first 6 hours of life

*If colostrum is of poor quality then a supply of high quality stored colostrum may be used or alternatively sourced fresh from another dam. Good quality surplus colostrum should be collected and stored frozen in quantities required for consumption.

If storing colostrum:

- Ensure that this is done within 1-2 hours of collection
- Putting the surplus colostrum in zip-lock bags will allow it to be stored as flat as possible, which is important for the thawing process, as a thin, flat bag will thaw more quickly and more evenly than a block
- The bags should be labelled with the date collected, cow ID and measured quality
- Colostrum can be stored at -18 to -20°C for up to 1 year
- Frozen colostrum can be thawed in the refrigerator overnight and then warmed in a water bath of no more than 50°C so the colostrum reaches ~40°C. Do not thaw or heat the colostrum in a microwave as this will destroy the antibodies
- Once the colostrum has been warmed (check the temperature using a thermometer), ensure that it is used within 30 minutes

When good quality colostrum is not available, colostrum replacer powder can be used but it will often not provide an equivalent level of immunity compared to the cow's own colostrum. Calves should only receive colostrum from their own dam. Colostrum and milk from known Johnes positive cows should not be fed to any calf.

How to stomach tube feed calves

Preparation	Ensure the stomach tube and bottle/bag is clean
	Heat the colostrum in a water bath to 38°C - 40°C
Handling the calf	Rest the calf in the corner of your arm with one hand under its muzzle
	Be aware of the dam's maternal instinct. The best place to feed the calf may be in separate accommodation.
	Ensure the stomach tube length is marked to represent the length from the calf's nose to its elbow.
Inserting the Tube	Moisten the tube with either warm water or colostrum
	Raise the calves head and slowly push the tube over the tongue to the back of the mouth
	The tube should enter the oesophagus positioned directly above the windpipe.
	Stop immediately if you feel any resistance – pull out slightly and redirect
	Insert the tube to the mark
Checking placement	The wind pipe is naturally a harder structure with rings obvious to the touch while the oesophagus is a softer collapsible structure
	When the tube is in the correct position it will inflate the oesophagus meaning that both structures can be felt
Administer colostrum	When the tube positioning checks are carried out and the calf is in a comfortable state tube feeding should commence.
	Control the feed by raising or lowering the bag. Keeping the bag low will be more comfortable for the calf ensuring the calf regurgitates less.
	Once the colostrum is finished kink the tube and withdraw it in one swift movement. (This prevents any liquid within the bag entering the lungs)
Cleaning the equipment	Immediately after use the feeding tube should be rinsed and thoroughly cleaned and disinfected.
	Hang the tube in a clean dry environment so it can drain and dry.

For more information and videos on colostrum feeding go to the AHDB Dairy Youtube Channel

Common Calfhood Diseases

Take home messages:

1. Calfhood disease affects calf growth causing reduced performance, productivity and profitability
2. Scouring and digestive disorders account for 40% of calf mortality within the first month of life
3. Good colostrum management, vaccination of dams and disinfection of calving pens reduces the risk of disease development

Calfhood diseases can substantially reduce heifer survival and the economic return on the dairy farm by both direct losses from calf mortality and morbidity as well as indirect effects on lifetime yield.

Sustaining poor performing calves and overcoming incidences of ill health whilst supporting heifer development can lead to increased costs and workload. It is good practice to keep accurate records of episodes of illness to measure animal performance and manage disease risks on farm. Infectious disease can be introduced by a number of sources such as:-

a) The introduction of animals
b) Vehicles, equipment, clothing and footwear of people who move between herds
c) Contaminated feedstuff and/or water
d) Other species such as dogs, cats, wildlife, birds and insects

It is vital, therefore, to have a biosecurity plan in place to prevent disease entry and control the spread of infectious agents. The All-Island Disease Surveillance Report, 2016 by AFBI and DAFM, shows that the most common causes of calf ill health to be related to enteric and/or respiratory infections. In 41% of cases submitted to AFBI laboratories, neonatal calf death was due to gastrointestinal related disorders such as scour, whilst respiratory infections accounted for 14% of calf mortality within the first month of life and 49% in calves of 1-5 months of age (Figure 9).

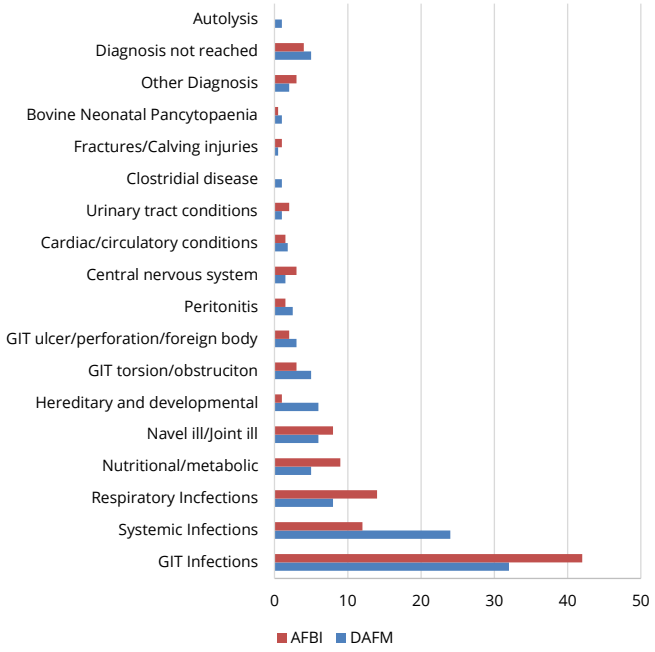


Figure 9: Post Mortem analysis of neonatal calves less than one month old (AFBI, DAFM 2016)

"Discussing options for the prevention and treatment of disease with your veterinary surgeon is advisable."

Prevention is always better than cure and strategies to help avoid the introduction of disease are discussed later in this section. However, below is a guide to the common causes and treatments available for calf scour and pneumonia. Remember that discussing options for the prevention and treatment of disease with your veterinary surgeon is advisable.

Scour

Causes

Scour can have either a nutritional or infectious cause. Nutritional scours generally result from changes in management routine, and can predispose calves to infectious scour due to a high pathogen load within the environment. Infectious scour is caused by viruses, bacteria and parasites, and can often be as a result of more than one infectious agent (Table 3).

Table 3: Causes of calf scour (adapted from Teagasc)

	Cause of scour	Typical age at apperance of clinical signs
Bacteria	E. coli	<5 days
	Salmonella	2-6 weeks
Parasite	Cryptosporidia	First week of life
	Coccidia	3-6 weeks
Viruses	Rotavirus	1-3 weeks
	Coronavirus	1-3 weeks

Cryptosporidium and rotavirus are the most common infections detected and were present in over 50% of faecal samples recorded by AFBI in 2016 (Figure 10). Cryptosporidium parvum is a parasite which causes damage to the small intestine leading to scouring. C. parvum shed oocysts which are passed in the faeces, contaminating the environment. Rotavirus and coronavirus are typically recorded at 1-3 weeks of age but can be mitigated by intake of sufficient colostral antibodies and adequate immune status.

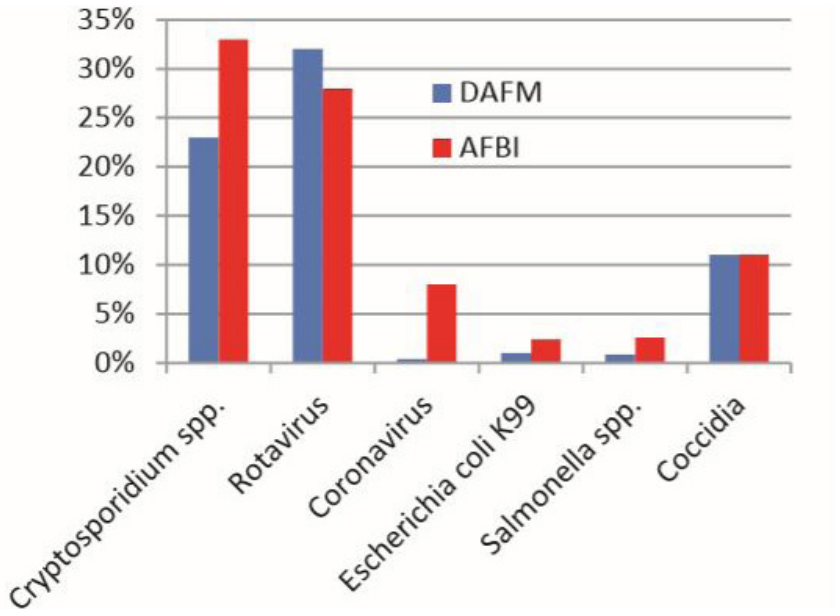


Figure 10: Relative frequency of enteropathogenic agents identified in calf faecal samples tested by AFBI and DAFM laboratories in 2016
(Source: AFBI, DAFM 2016)

These viruses are commonly found in calves and can cause reduced absorption by the intestine resulting in diarrhoea. Common bacterial causes of scour include strains of E. coli and salmonella. All causes of infectious scour are transmitted through the faecal-oral route. The disease causing organisms are passed in the faeces, contaminating the environment and thus exposing other animals in the same environment to the organism. It is therefore critical that the environment where the calf is born and reared during the first weeks of life are kept as clean and free as possible free of adult and calf dung. Where a calf is ill it should be immediately isolated from other calves so as to limit the spread of infection.

Symptoms

- Increase in frequency of defecation and quantity of faeces produced
- Faeces appear loose due to the increased water content
- Change in faecal colour or appearance
- Blood in faeces
- Calves can appear depressed/weak and are reluctant to feed
- Weight loss or reduction in daily live weight gain
- Dehydration can result in skin tenting, sunken eyes and pale, sticky oral mucous membranes
- Infectious scour can increase core body temperature outside of the normal range (over 39.5°C)

Treatment

In order to limit the exposure of other calves it is essential to isolate scouring calves. It is very important to take care to avoid the spread of infection on footwear. Calves should be placed in a clean, dry pen and bedding should be refreshed regularly. Keeping the calves warm by providing sufficient bedding for nesting, or through the use of a heat lamp or calf jacket is advised. As scour can result in dehydration due to the increased water content of the faeces, it is vital to ensure that calves receive sufficient fluid. Providing calves with a constant supply of fresh, clean water and administering electrolytes between milk feeds will help to replace any lost fluids. It is essential to continue to offer milk or milk replacer as this will provide the calf with energy required to fight the infection and can also help to heal the intestine. However, it is important that milk/milk replacer is not stomach tubed.

Non-nutritional scour is most commonly caused by viruses or parasites, which cannot be treated with antibiotics, however some therapeutic options for Cryptosporidia are available. Antibiotics should only be administered if the calf has a temperature outside of the normal range (38.5-39.5°C), the calf looks very sick or on the advice of your veterinary surgeon. If a group of calves are showing signs of scour, taking a sample prior to any treatment can help to determine the cause and, if bacterial, indicate which antibiotic will provide the most effective treatment. Hygiene practice in and around pens should be examined to ensure competent and correct use of disinfectants.

"In order to limit the exposure of other calves it is essential to isolate scouring calves. It is very important to take care to avoid the spread of infection on footwear."

Pneumonia

Causes

Respiratory infections are the most frequent cause of death in 1-5 month old calves (Figure 11) and weanlings aged 6-12 months (Figure 12) accounting for over 40% of post mortem results in Northern Ireland (AFBI/DAFM 2016). Pneumonia can be caused by bacteria, viruses and parasites (Table 4). Its onset can also be triggered as a result of environmental and management conditions such as poor hygiene, insufficient colostrum, poor ventilation and stress so it is often referred to as a multifactorial disease. The bacterial causes of pneumonia are often carried by healthy calves with disease precipitated by other factors such as the environment.

Pneumonia not only results in higher husbandry and veterinary costs but research at AFBI has also shown pneumonia affects future performance, with a 13kg reduction in live weight at the point of calving as well as 5-10% difference in first lactation milk yield. High risk periods of respiratory distress are notable during mixing of calves into group pens, after weaning and changeable weather conditions/fluctuations in ambient temperature. It is therefore advisable to avoid concurrent stress factors e.g. regroup calves 1-2 weeks after weaning rather than at weaning.

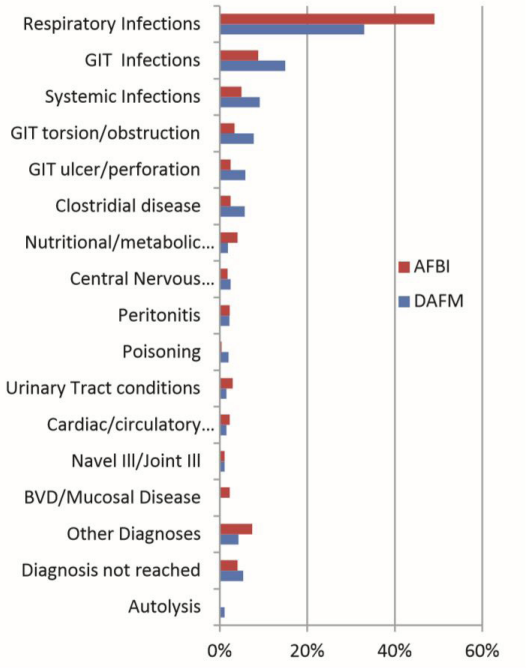


Figure 11: Conditions most frequently diagnosed on post-mortem examination of calves one to five months old by DAFM (n=800) and AFBI (n=442) in 2016 (Source: AFBI, DAFM, 2016)

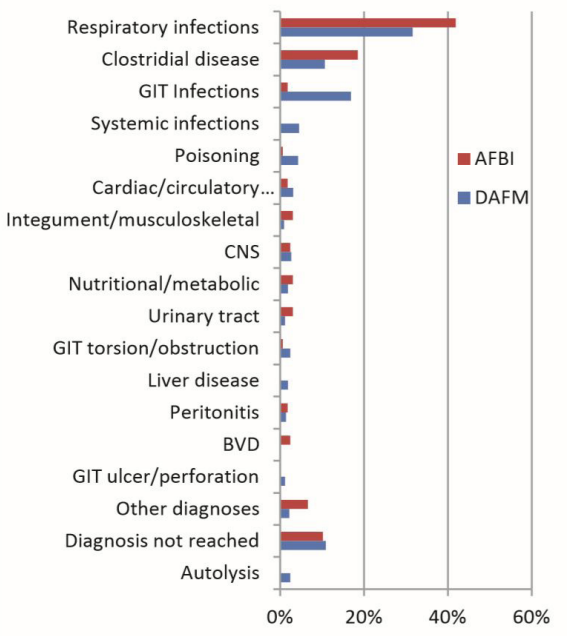


Figure 12: Conditions most frequently diagnosed on post-mortem examination of weanlings (6 to 12 months old by DAFM (n=421) and AFBI (n=167) in 2016 (Source: AFBI, DAFM, 2016)

Table 4: Common causes of bovine respiratory illness (Adapted from Teagasc)

	Cause of Respiratory illness
Parasites	Dictyocaulus viviparous (Lungworm)
Bacteria	Mannheimia haemolytica
	Pasteurella multocida
	Trueperella pyogenes
	Histophilus somni
	Mycoplasma bovis
Viruses	Respiratory syncytial virus (RSV)
	Parainfluenza type 3 (Pi3)
	Infectious bovine rhinotracheitis (IBR) (Bovine Herpes Virus 1)
	Bovine viral diarrhoea (BVD)

Symptoms

If treatment of pneumonia is to be successful, early diagnosis is essential. Initial signs and symptoms of pneumonia can include:

- Dullness or generally being off form
- Reduction in feed intake
- Breaks in milk feeding and a reduction in drinking speed
- Fever (core temperature > 39.5°C)
- Increased respiratory rate or 'blowing'
- Discharge from eyes and nose
- Tilted or dropped ear position
- Repeated coughing

Treatment

Veterinary advice should be sought as early as possible when treating pneumonia. The appropriate treatment will be dependent on a range of factors including the likely cause of pneumonia, the clinical state of the animal, and the history of infection in both the animal and the herd. The decision on whether an antibiotic treatment is needed and if so what antibiotic is likely to be the most appropriate, should always be taken in conjunction with your veterinary surgeon. Where an antibiotic is indicated, it should be used at the recommended dose rate and the full course given. It should be noted that there are no antibiotics available that are effective against any of the viral causes of pneumonia. However, antibiotics may still be indicated in such cases to prevent secondary bacterial infection. Close monitoring of calves on a regular basis is needed, particularly outside feeding times when calves are resting, to detect any changes in behaviour. It is always better to try and prevent pneumonia rather than treat outbreaks. It is advisable to develop a vaccination programme with your vet that is likely to confer immunity to those animals that are most susceptible to pneumonia ahead of when they are mostly likely to develop pneumonia

Prevention of disease

- Discuss the implementation of a vaccination programme for dams and youngstock with your veterinary surgeon
- Disinfect the calf's navel as soon as possible after birth - preferably within a few minutes
- Provide 10% of birth weight of good quality colostrum within the first 6 hours after birth – colostrum from vaccinated dams can help to prevent viral causes of scour
- Maintain high levels of hygiene within the calving pen and calf rearing accommodation to limit the spread of infection - clean bedding, feeding buckets/equipment and water drinkers are vital
- Isolate calves as soon they are observed showing signs of ill-health
- Monitor the environmental conditions within the rearing accommodation to ensure that there is sufficient ventilation to provide clean, fresh air whilst avoiding extreme temperature fluctuations and drafts at animal level
- Provide clean, easily accessible drinking water
- Feed adequate amounts of high quality calf milk replacer and concentrates – monitor feed intake to identify any animals that may have a depressed appetite
- Record incidences of ill health and treatments provided to identify patterns within individual or groups of calves

Long Term Impacts of ill health in early life

Identifying ill health early enables appropriate intervention to treat sick calves and prevent ongoing poor performance. it is important to take note of the episodes of illness to identify probable causes. Insufficient intake of colostral antibodies during the first 24 hours of life may contribute to calf health problems in the pre-wean period. Data analysed by AFBI found that calves with failure of passive transfer (FPT) were more susceptible to episodes of ill-health later in life.

In order to prevent calf loss it is important to be aware of the major threats and have measures in place to prevent detrimental effects on their performance. Table 5 outlines the impact of incidences of scour, pneumonia and dullness on target growth. The reduction in live weight gain results in longer periods to meet breeding and calving targets, which can result in a decrease in overall milk yield. These factors have a negative impact on production and makes recovery of heifer rearing costs much more difficult. Preventative measures taken on farm alongside prompt diagnosis and treatment of disease is necessary to safeguard against the introduction and spread of infection within heifer rearing facilities.

Table 5: The effect of ill-health on live weight from 8 weeks to 1st calving disease

	Type of illness diagnosed			
Live weight (kg)	None	Scour	Pneumonia	Dullness
8 week	69	64	62	63
6 month	162	155	152	152
1 year	295	284	281	279
1.5 year	432	383	414	416
Calving	534	518	522	509

*Dullness likely linked to be pneumonia

With the recent concern regarding the use of antibiotics on farm, mitigating their use can be achieved by reducing pathogen loads within the rearing environment and enhancing immune status of the calves through vaccination programmes and provision of adequate colostrum and nutrition. Additionally, providing staff with appropriate training and clear management and health plan protocols is vital.

RECOMMENDATIONS

- Have a biosecurity plan in place to limit potential introduction and spread of disease
- Ensure all staff are trained and have a healthy attitude to biosecurity
- Target improved hygiene in calving pens and do not use calving pens for sick cows
- Ensure calf pens are thoroughly washed, disinfected and dried out between calving seasons and at least freshly bedded between each calf use. All year round (AYR) calving herds should target pens to be thoroughly cleaned between each calf use
- Review and revise hygiene protocols to see where improvements can be made
- Ensure health records are kept up to date to monitor veterinary treatments and ongoing performance – develop health plans with your veterinary practitioner and train staff in their implementation. Prevention is always better than cure – employ a routine vaccination strategy to mitigate the risk of disease outbreaks and need for treatment
- Review health data to target problem areas

Bio security principles

There are four major components to prevent disease entering:-

1. Minimise the purchase of replacement stock

If purchasing is necessary, only purchase animals from known sources with proven health status equal to, or greater than your own herd. Check health records, the status of the animal, and find out the vaccination history of animals prior to purchase. For some diseases, pre-movement tests can be useful to provide confidence for purchasers. However, some diseases such as Johne's Disease, pre-purchase testing has limited use. In these cases seek assurances about the health status of the vendor's herd. Develop a protocol to assist decision making around purchased animals.

2. Isolation following purchase

Strict isolation to prevent contact between animals after arrival will reduce the risk of spreading infectious agents. Quarantine all new animals under veterinary guidance and carry out any relevant tests as required if health status is unknown.

3. Movement control

Limit the entry and exit of all vehicles, animals, and people on farm that could introduce infection. Permit only essential personnel and equipment access to animals and their accommodation.

4. Sanitation

Avoid sharing equipment and machinery. Where this is unavoidable, clean and disinfect equipment/machinery before re-entering your farm. Provide dedicated farm clothing to farm visitors. Use different equipment to clean out and feed quarantine animals. Ensure personal hygiene is upheld by cleaning and disinfecting at entry and exit of quarantine and sick animal facilities.

Calving Pen and Calf House Hygiene

Calving pen hygiene is critical in order to reduce the risk of infection for newborn calves. In a recent survey of 66 Northern Irish Dairy farms, almost two thirds of producers bed up the calving pen daily or after every cow, with the remainder bedding up once, twice or three times a week. There is a wider range of practices with cleaning out calving pens, with half of producers cleaning out daily or after each or every other calving, or weekly, or fortnightly. More than a third are only cleaning out monthly, and the remainder at significantly longer intervals. The predominant assessment showed that 20% of calving pens had poor hygiene scores. There is therefore room to improve hygiene practice in and around calving pens. Over 20% of calving pens were considered to be difficult to clean. A third of farms also use the calving pen for downer cows.

Cleaning

It is vital to reduce the risk of disease spread from every angle. It is important to set good hygiene standards and train all staff in appropriate cleanliness and handling requirements.

- Use waterproof clothes and appropriate footwear which can be cleaned and disinfected
- Provided dedicated clothing to all people entering calf rearing areas
- Install disinfectant footbaths at entry to the calf house to mitigate disease spread and use the correct disinfectant according to manufacturers directions
- Where possible, work from young animals towards older animals
- Wash thoroughly all feeding utensils such as stomach tubes, teated buckets, colostrum churns etc., rinsed initially in cold water, then in 60ºC hot water with detergent
- After washing, soak equipment in disinfectant for a minimum of 30 minutes or as per label
- Ensure items are rinsed well prior to drying
- Dry equipment off the floor

Hygiene practice in the calf house is widely variable, confounded by the variety of facilities some of which are not easy to clean. Attitudes towards the relative importance of hygiene varies widely between farms, which has a significant impact on the availability and willingness to devote time and space to clean facilities properly.

Almost 80% of farms are cleaning single pens between each calf use, and similar numbers are cleaning group pens between batches. Assessment of pen cleanability found that almost half of all pens on participating farms were rated as easy to clean, with 25% rated as mostly reasonable. The main issues were the extent of broken surfaces within the animal zone and the presence of engrained biofilm on pen walls and divisions. Biofilm, a build-up of microorganisms such as bacteria found on many different surfaces, is a hazard because a number of pathogens can live in the biofilm where they are protected from most disinfectants.

There were a range of hygiene practices adopted for milk and feed preparation, indicating significant room for improvement on many farms. Almost half of farms clean buckets after every feed or daily, with 20% cleaning buckets weekly and a further 20% keeping buckets with individual calves and not cleaning buckets until weaning.

The ability to clean feeding equipment frequently and effectively would be greatly helped if facilities were available and accessible to wash items and dry them off the floor, easily. There is excellent potential within the industry to have a better dialogue on what is realistically achievable with cleaning, with suitable preparation, correct disinfectants and immersion times, and effective drying being the main requirements.

These simple steps below can help to give the calf the best start in life.

Clean calving pen out between each calving → Power hose pen leaving it spotlessly clean → Allow pen to dry → Spray with disinfectant according to application rates

It is recommended to seek veterinary advice on developing an on-farm hygiene plan that includes the appropriate use of effective disinfectants. Pathogens responsible for calf infections range in strength and resistance and can be produced from viruses, bacteria or parasites. The disinfectant used must have a spectrum covering these three types of organisms. A constraint for implementation of recommended hygiene practices on many farms is availability of staff. However, the implementation of simple but effective routine hygiene protocols suited to your specific farm and staff availability will help yield improvements in animal health and performance.

"The predominant assessment showed that 20% of calving pens had poor hygiene scores. There is therefore room to improve hygiene practice in and around calving pens. Over 20% of calving pens were considered to be difficult to clean. A third of farms also use the calving pen for downer cows."

Health Records

It is important that all veterinary treatments administered are recorded to ensure full drug traceability and to catalogue periods of ill health. Medicine records allow for regular reviews to be carried out on disease incidences, the effectiveness of treatments, and the planning of future preventative and treatment protocols. Standard operating protocols makes it easier to provide a quality management system and maintain animal handling and welfare on farm by standardising routine procedures. A reliable working environment with well trained staff is vital to track animal performance and introduce preventative measures. The profile of the animal's background is useful in predicting later performance and estimating return on investment.

An example of a veterinary record sheet is given below.

Date	Calf No (5digit)	Treatment 1	Quantity1 (ml)	Batch 1 no	Treatment 2	Quantity 2 (ml)	Batch 2 no	Administered by

Date	Calf No (5digit)	Symptoms	Temperature

Standard operating procedures should be designed as visual guides to manage critical steps in routine on-farm procedures. This should include routine vaccination which plays a major role in disease prevention. Ensure staff are trained in the protocols established on farm and review them regularly to update and maintain the best farming practice.

Vaccination strategy

It is important to seek veterinary advice to review the health status of your herd and establish a herd health plan. Vaccines are an important tool for securing herd health as they limit the spread of infection between animals. The goal is to provide optimal protection against disease, which requires strategic planning. Depending on the vaccines used and the infections targeted, vaccines must be used at the correct time in animals of the appropriate age and type to maximise their effectiveness.

What should you vaccinate for?

In order to develop an effective vaccination program for your farm it is important to liaise with your vet to identify which diseases to target. Vaccines now exist for a very wide range of disease-causing organisms. Vaccinations cannot however compensate for an unsanitary environment, poor ventilation or existing poor health, and vaccine failure can occur if other stresses on a calf are too great. A common reason vaccines don't work is failure to use them as recommended by the manufacturer – this including storage temperatures.

Effective vaccination

Variables which influence the efficacy of your vaccination strategy should be discussed with your vet. The timing of vaccine delivery is crucial to ensure effective immunity is established. It is advisable to place a thermometer where vaccines are stored to allow regular monitoring of temperature. Always check the correct dosage. Ensure the correct site of application and route for vaccine administration (subcutaneous, intramuscular, intranasal) and check needles and syringes are sterile and of the appropriate size.

"It is important to seek veterinary advice to review the health status of your herd and establish a herd health plan."

Pre-Wean Nutrition

Take home messages:

1. Provide calves with sufficient milk or CMR to achieve daily live-weight gains of at least 0.6 kg/day in the pre-wean period
2. An unlimited amount of clean, fresh water must be provided to calves from birth alongside their milk supply
3. Starter concentrate consumption is essential for rumen development and should be encouraged from the first week of life
4. Providing a high quality fibre source such as chopped straw from early life can help to improve post weaning performance and promote rumen development during the pre-wean period

Optimal daily live weight gain during the pre-wean period can help achievement of key growth targets and has also been associated with increased 1st lactation milk yield. These long-term benefits have been attributed to enhanced mammary gland and lean muscle development and possible enhanced efficiency at a molecular level. With the calf starting life effectively as a monogastric and developing into a ruminant, pre-wean nutrition may have long term impacts on rumen development.

Nutritional Requirements

During the first 3 weeks of life energy requirements should be met through whole milk or calf milk replacer (CMR) as calves generally do not consume much concentrate within this period. Historically a newborn calf is provided with two daily feeds of 2L milk or milk replacer. This equates to 10% in volume of birth weight for a 40kg calf. However, not all calves are 40kg and heavier calves require more nutrients to meet basic energy demands.

The National Research Council guidelines (NRC 2001) indicate calves weighing 45kg have a daily metabolizable energy requirement of 7.3 MJ. Whole milk contains around 2.13 MJ per litre, therefore a 45kg calf would require 3.4L of whole milk just to meet the maintenance energy requirements for the basic functions needed to stay alive. Additional energy is needed for growth and development of bone and muscle and only nutrients in excess of the maintenance requirements are able to support growth. Inadequate energy provision will therefore have consequent negative effects on calf development and performance (Table 6).

Live weight (kg)	Daily live weight gain (kg/d)	ME maintenance (MJ/d)	ME growth (MJ/d)	Total ME (MJ/d)
35	0.4	6.04	4.15	10.19
	0.6		6.75	12.79
	0.8		9.54	15.58
40	0.4	6.68	4.35	11.03
	0.6		7.08	13.76
	0.8		10.00	16.68
45	0.4	7.3	4.54	11.84
	0.6		7.38	14.68
	0.8		10.43	17.73
50	0.4	7.9	4.71	12.61
	0.6		7.66	15.56
	0.8		10.82	18.72
55	0.4	8.48	4.87	13.35
	0.6		7.93	16.41
	0.8		11.20	19.68
60	0.4	9.05	5.03	14.08
	0.6		8.18	17.23
	0.8		11.55	20.60

Table 6: Energy required to enable growth at 0.4 - 0.8 kg/day in ambient temp of 15-20°C for calves fed milk or milk replacer (adapted from AHDB/NRC)

*Maintenance energy requirement calculated as (0.1 x live weight0.75) x 4.2
Maintenance energy for growth calculated as (0.84 x live weight0.355 x (ADG1.2)) x 4.2

The first three weeks of life are also a time when calves are most vulnerable to changes in environmental temperatures. During this time, their lower critical temperature is between 10 - 15°C, meaning in temperatures below this energy is diverted away from growth and development and used to maintain body temperature. In calves over 3 weeks of age the lower critical temperature drops to around 5 - 10°C. To help mitigate the effects of low temperatures, one option is to increase the provision of milk or CMR (Tables 7 and 8).

Table 7: Estimated additional MEm (MJ/day) required for 50kg LW calf aged 0-3 weeks

Calves 0-3 weeks				
Temp °C	Temp °F	Extra MEm	Mem	Total Mem
20	68	0.00	7.87	7.87
15	59	1.06	7.87	8.93
10	50	2.11	7.87	9.98
5	41	3.17	7.87	11.04
0	32	4.23	7.87	12.10
-5	23	5.29	7.87	13.16
-10	14	6.34	7.87	14.21

Another option is to provide the calves with an external heat source such as a heat lamp or added insulation with a calf jacket. In a recent AFBI study, skin surface temperature was 7°C higher in calves provided with a jacket for the first three weeks of life compared to those without jackets. Additionally calves not provided with jackets showed behavioural signs of increased hunger and consumed more concentrate as a means of trying to increase energy intake.

Table 8: Estimated additional calf milk replacer for 50kg LW calf fed CMR containing 19.9MJ/kg ME (adapted from Calf Note #121; www.calfnotes.com)

g/d additional milk replacer			
Temp °C	Temp °F	0-3 wks	>3 wks
10	50	106	0
5	41	159	53
0	32	213	106
-5	23	266	159
-10	14	319	212

Calf Milk Replacer vs Whole Milk

Whole milk can have a higher energy density compared with CMR and is superior in terms of digestibility, particularly in calves under 3 weeks of age. However, it can be more expensive to feed whole milk when compared to saleable milk prices and there is a greater risk of disease transmission. Additionally, high levels of fat in whole milk have been suggested to delay solid feed intake and rumen development, whereas digestible milk proteins in milk replacer can be tuned to encourage starter uptake.

Benefits of feeding CMR are the consistency of the energy and vitamin and mineral content of the feed and the lower disease risk, however, when it comes to CMR it is important to assess the quality of the constituents you are feeding. As the only legal requirement for declaration of ingredients in CMR is that they be listed in descending order of inclusion, it can be very difficult to assess CMR quality.

Calf milk replacers are highly variable in specifications, ranging between 16-28% fat and 19-28% protein depending on the specific requirements, methods of application and target objectives. Milk proteins in CMR are either skim or whey based. The casein content of skim based CMR forms a clot in the abomasum which allows it to be digested in the same way as whole milk, whereas whey based powders do not contain casein, do not require pre-digestion in the abomasum. In young calves, particularly for those under 3 weeks of age, it is important that the CMR contains predominantly milk derived proteins from selected whey and/or skimmed milk sources.

Quality of CMR is dependent on the digestibility of selected protein sources (milk and/or vegetable based) and appropriate balance between fat sources (milk and/or vegetable based). In instances where protein and fat sources are not balanced, some vegetable proteins such as soy and wheat gluten can result in nutritional scours and limit growth, feed efficiency and digestibility and vegetable fats such as coconut, palm oil or soybean can also pose a risk of scour to calves under 2 weeks of age. Fibre content of CMR is considered an indicator of protein quality. Generally, CMR with a fibre content less than 0.15% is associated with inclusion of milk or egg, with fibre contents above 0.20% indicating inclusion of plant proteins. Ash content may vary between 6-8% and is an indication of overall mineral level and should not be above 8%.

"Calf milk replacers are highly variable in specifications, ranging between 16-28% fat and 19-28% protein depending on the specific requirements, methods of application and target objectives."

Feeding Level

Calves need to gain at least 0.6-0.7 kg/day in the first months of life to achieve growth targets for breeding. However, higher growth rates, linked to improvements in future performance, can be achieved through feeding more than the traditional 4 L/day, feeding a higher concentration of CMR (if the type of CMR allows) or through a balanced combination of higher volume and concentration of CMR. Provision of larger milk volumes can increase the calf's nutrient intake and therefore allow improved live-weight gain and can result in improved feed conversion efficiencies. However, results from research have been varied, with some studies indicating that the live-weight advantage gained by calves fed increased volumes of milk or CMR can be lost in the post-wean period.

Recent research by AFBI, investigating feed efficiency of calves from birth to conception, found calves on an accelerated CMR level of up to 9L (1350g) per day achieved higher pre- and post- wean live weights compared to calves on a conventional 4L (600g) per day feeding regime (Figure 13).

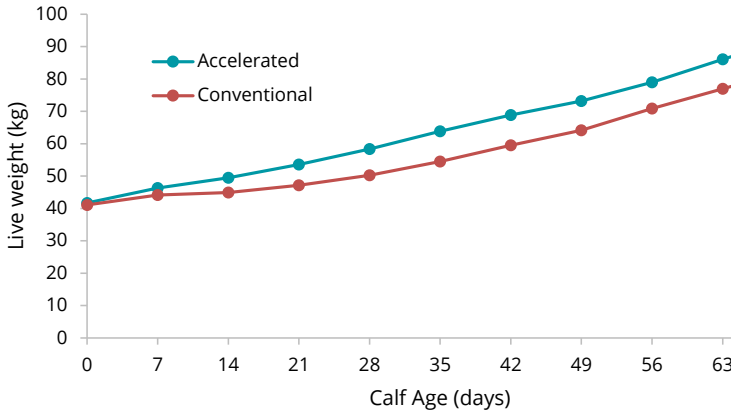


Figure 13: Live weight of calves on conventional or accelerated milk replacer levels in the pre-wean period

Calves on the accelerated CMR program were stepped down from 9L to 6L of milk allowance on day 42 and further reduced to 3L by day 57 with all calves on 2L by day 68. Accelerated calves were 10.4 kg heavier by day 70 and maintained their live weight advantage right through to 16 months of age. This live-weight advantage is beneficial in heifers as it can reduce age of puberty and help to achieve a first calving age of 24 months. Additionally, previous work in the USA has shown that increasing pre-weaning average daily gain by 0.2 kg/day results in an average 222 kg increase in first lactation milk yield.

One concern is that increased provision of CMR has a tendency to reduce concentrate intake which could impact on rumen development and performance in the post-wean period. In the recent AFBI study, accelerated milk fed calves consumed less concentrate from birth to 55 days of age, however from day 56 onwards, accelerated milk fed calves consumed higher levels of concentrate on a daily basis until weaning (Figure 14).

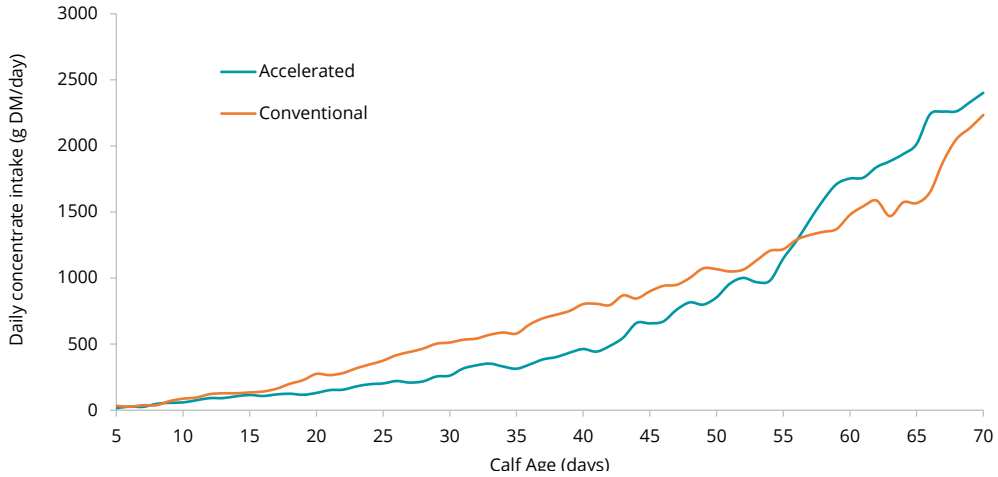


Figure 14: Concentrate intake of calves on conventional or accelerated milk replacer levels in the pre-wean period

On average, accelerated CMR calves were consuming 56g more concentrate per day. Total dry matter intake for calves on the higher CMR level was 1.61kg compared to 1.28kg which meant they were able to maintain their growth advantage through weaning. If feeding higher levels of milk or CMR, adopting a step-up/step-down milk feeding regime is advisable as this can help to establish calves on solid feed prior to weaning which allows them to maintain their live weight advantage post weaning.

It is important to set target growth requirements throughout the rearing period and provide calves with sufficient energy to meet expectations. Additionally, cost of feeding accelerated levels of milk or CMR has to be factored in and targets for breeding age and age at first calving (AFC) must be met in order to balance the increased financial inputs. There are a wide variety of options which are designed to offer a plane of nutrition between conventional and accelerated CMR levels.

Choosing a feeding schedule which combines the best aspects of both approaches will offer intestinal satiety, appropriate growth rates and encourage early rumen development, this helping calves to avoid a post-weaning growth check. In the pre-wean period and in order to meet growth targets for breeding, calves should be fed enough to grow at a rate of at least 0.6 kg/day. With these considerations it is advisable to feed 15% of calf bodyweight in either whole milk or CMR e.g. a 40 kg calf should be fed a daily amount of at least 6 L of milk or CMR at a rate of up to 150 g/L. Paying appropriate attention to feeding level and feeding frequency can help to avoid feeding very high levels of milk or CMR per feed in the first two weeks of life when the abomasum is of limited size and stretch.

Feeding frequency

Unless you use an automatic milk feeder which can be programmed to deliver feed throughout the day, the daily milk or CMR volume is generally split into a morning and afternoon feed. Once daily feeding is considered a method of reducing labour input. However it is important to note that calves should not be fed once daily until they are consuming a sufficient amount of concentrate, which is generally not until calves are at least 4 weeks of age.

A recent AFBI study found comparable performance between calves fed 625g CMR once daily from 28 days of age and those fed the same amount split into two feeds, with calves across both treatments achieving an average daily gain of 0.7 kg/day between birth and weaning. If feeding increased levels of milk it may be advisable to split this into three feeds per day to allow ease of digestion. It should also be remembered that increased levels of milk or CMR will result in increased urine production and generally looser faeces so it is very important to ensure that bedding is kept dry and clean.

Top tips for milk feeding

- Use clean, debris free equipment to weigh out and mix your milk powder
- Milk or CMR should be fed at body temperature around 38-42°C
- Ensure that CMR is mixed thoroughly to an even consistency as per instructions
- If using an automatic feeder, carry out performance checks on a fortnightly basis to ensure correct amounts are being fed
- Teat feeding helps to encourage salivary production which aids digestion. It also helps calves to satisfy their urge to suckle and stimulates a functional oesophageal reflex thus preventing rumen drinking
- If using CMR, ensure it is reconstituted at the appropriate concentration to achieve targeted growth e.g. if feeding 6 L/day at a 15% reconstitution rate this means 900g of powder + 5.1 L of water

Remember – when using CMR, failure to follow manufacturer's instructions can impact negatively on calf performance!

Concentrate Provision

When calves are born the rumen is small, under developed and cannot contribute to digestion. Solid feed consumption contributes to the muscular development and expansion of the rumen whilst volatile fatty acids (VFA) produced from the digestion and fermentation of ingested solids stimulates the development of the rumen papillae. Production of VFAs also helps to lower the rumen pH which creates an ideal environment for growth of bacteria which help to facilitate digestion. Both butyric and propionic acid are produced from bacterial digestion of the starch in concentrate feed and are a vital energy source for both development of the rumen wall and calf growth.

Calves do not consume much concentrate feed in the first weeks of life, however, small fresh amounts of concentrate feed should be provided on a daily basis from the first week of life in order to encourage consumption. Hand feeding a small amount of concentrate after the milk feed can help to stimulate a calf's interest and encourage consumption. Providing free access to clean, palatable water can also help to encourage concentrate intake. Concentrate palatability in terms of taste and smell are also important to encourage intake so providing a fresh ration, free from mould or dust on a daily basis is vital. Coarse (ingredients of a similar size) or pelleted ration (commonly 3 to 5mm pellets) are preferred to fine dusty meals which can reduce intake and lead to respiratory and digestive disorders. If feeding a coarse ration it is very important to ensure that each ingredient is palatable so as to avoid feed sorting which could impact on nutrient intake balance.

The benefits of offering a pelleted ration are that feed sorting is not an issue and they also tend to be cheaper than coarse rations. A recent study conducted at AFBI compared the impact of offering concentrate starter ration as either a 3mm or 5mm pellet during the pre-wean period. No significant impact on live weight at weaning was found between treatments, however, live-weight gain between birth and weaning was comparable across treatments despite calves offered the 3mm pellet consuming 4.1 kg/head less concentrate during the same period. Concentrate intake can vary widely between individual calves – monitoring concentrate intake can help to assess readiness for weaning and also help to limit feed wastage.

Table 9: Typical nutrient requirement of calf starter concentrate (Source: Teagasc/NRC 2001)

Nutrient Specification	
Minerals	
Crude Protein	18%
Calcium	0.7%
Phosphorus	0.45%
Magnesium	0.10%
Sodium	0.15%
Potassium	0.65%
Chlorine	0.20%
Sulphur	0.20%
Iron	50 mg/kg
Zinc	40 mg/kg
Managanse	40 mg/kg
Copper	10 mg/kg
Iodine	0.25 mg/kg
Cobalt	0.10 mg/kg
Selenium	0.30 mg/kg
Vitamins	
Vitamin A	4000 IU/kg
Vitamin D	600 IU/kg
Vitamin E	25 IU/kg

Choosing a concentrate ration that meets the calf's nutrient requirements is vital for maintenance of performance and health. Starter rations should have an energy content of no less than 12 MJ/ kg on a dry matter basis and should contain 16-18% crude protein on an as fed basis. The nutrient content of a typical starter ration is shown above (Table 9).

"When calves are born the rumen is small, under developed and cannot contribute to digestion. Solid feed consumption contributes to the muscular development and expansion of the rumen whilst volatile fatty acids (VFA) produced from the digestion and fermentation of ingested solids stimulates the development of the rumen papillae."

Forage

The inclusion of a forage fibre source early in calf development is important as it facilitates the growth of the muscular layer of the rumen whilst encouraging mastication at a young age. Forage provision is observed to enhance natural and social behaviour needed to prepare animals for grazing and promotes salivary production to improve rumen pH which helps to prevent acidosis (bloat). Studies have also shown improvements in rumen pH, average daily gain (ADG) and up to 30% increase in solid feed intake when calves were supplemented with forage. However, forage quality is very important for calf performance as providing a low quality, long stemmed, indigestible forage source can create a gut fill effect which can subsequently reduce concentrate intake.

Previous research conducted at AFBI found the live weight of calves was significantly improved when either grass or maize silage was included in the diet of pre-weaned calves compared to calves not provided with a forage source (Figure 15). More recently, an in depth digestibility study carried out at AFBI found that providing chopped straw from 14 days of life resulted in heavier calves in the post weaning period compared to those offered either chopped straw or grass silage from 56 days of age or those not provided with a forage source. It is likely that provision of chopped straw in early life improved rumen muscularity, this leading to a better performance post weaning. It is important that the forage source is unspoiled to encourage consumption. Straw bedding should not be considered a forage source as this could result in calves consuming contaminated bedding, leading to ill-health.

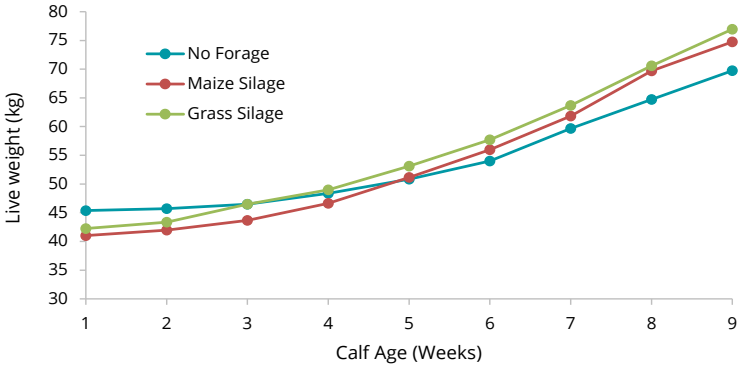


Figure 15: Increased live weight gain with forage inclusion of maize or grass silage during the prewean period compared to calves not offered forage (Source: AFBI Data)

Water Intake

Providing access to an adequate supply of fresh drinking water is a legal requirement. However, there is a wide range of attitudes amongst farmers towards the importance of access to unlimited, clean, fresh water in calf facilities. Water intake in early life is essential to drive early intake of dry feed, vital for early rumen development and fermentation of solid feed, and critical in fluid replacement if scours occur. Calves will drink less if access is difficult or the water quality is poor. In a recent on-farm survey of 66 Northern Irish dairy farms conducted by AFBI, water hygiene was assessed as good on only 10% of farms, and analysis of water samples indicate high concentrations of viable bacteria on most farms at pen level. Part of the issue may be that fixed drinkers are not easy to clean due to location and/or design. The recommendation is to have clean, palatable water in front of calves at all times, with drinkers located at the front of pens for ease of checking and cleaning.

AFBI studies have shown a dramatic increase in water consumption at weaning (Figure 16). Other research indicates limited access to water reduces concentrate uptake and subsequent live-weight gain. A recent AFBI study looking at feed efficiency from birth through to weaning, found no difference in water intake when calves were fed higher levels of milk replacer powder compared to conventional levels. Calves should continue to receive water in plentiful supply irrespective of milk feeding levels. Calves that were offered chopped straw as a forage source consumed greater amounts of water compared to those supplemented with grass silage or calves with no forage provision.

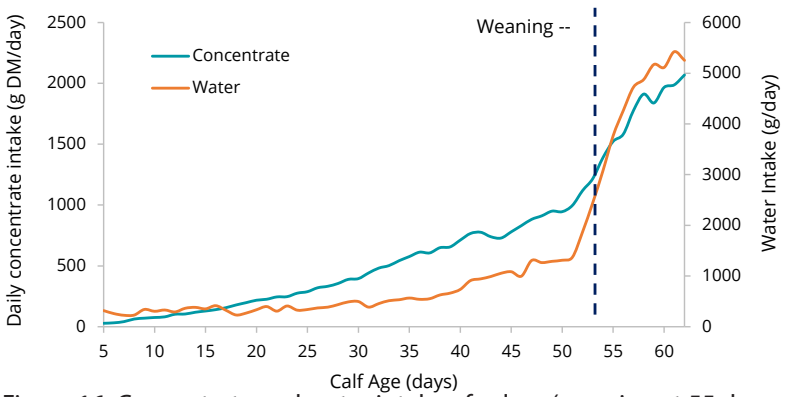


Figure 16: Concentrate and water intake of calves (weaning at 55 days of age (Source: AFBI data)

Weaning

The transition from liquid to solid feeding represents a stressful period for the animal therefore is it is important to ensure this is a smooth process, particularly when feeding higher levels of milk. Stepping down the milk level over a period of 1-2 weeks has been shown to encourage solid feed consumption compared to abruptly weaned calves. Depending on the system used, step-down weaning can be implemented by;

- reducing the milk feeding frequency
- reducing the volume of milk provided or
- reducing the concentration at which CMR is diluted

Although producers typically monitor milk intake, it is less common to monitor solid feed intake, however this is a very important indicator of a calf's readiness for weaning. Ensuring that calves are established on solid feed prior to weaning is important to avoid a slump in growth during the post-wean period. The increased use of computerised feeders assists the weaning process since individual concentrate intakes can be monitored to support milk reduction. Weaning can be initiated when calves are consuming 0.75kg – 1 kg/day (depending on breed) of concentrate containing greater than 22% crude protein content, or around 2 kg/day of concentrate containing less than 22% crude protein content, for at least 3 consecutive days. Research at AFBI demonstrated a reduction in weaning age and subsequent rearing costs when weaning was based on solid feed intake level rather than age and subsequent rearing costs when weaning was based on solid feed intake level rather than age.

Weaning was concluded when calves were consuming 1.5kg/day and no difference in live weight was noticeable at 20 weeks of age compared to calves weaned at a fixed age. Although some studies have reported that earlier weaning from 5 weeks of age can reduce labour and rearing costs, it must be remembered that growth is at its most efficient during the first two months of life. Maximising the use of milk of milk replacer during this time can lead to improvements in performance and health. Weaning is a significant stressor for calves and can leave them more vulnerable to ill-health for up to two weeks after weaning. It is advisable to avoid other management practices such as moving, mixing and vaccination for two weeks after weaning.

Remember: Deciding that calves are ready to be weaned should not be determined by one factor alone. It is important to take into account the live weight, general condition, solid feed intake and age of individual animals to ensure they have a smooth and successful transition to the post-wean phase.

> "Ensuring that calves are established on solid feed prior to weaning is important to avoid a slump in growth during the post-wean period."

Post-Wean Nutrition

Take home messages:

1. Keep calves on starter ration until they are 10-14 weeks of age then move to a 16% crude protein grower ration
2. Heifers need to grow at minimum 0.7 kg/day to meet target breeding and calving age
3. Know the energy content the diet – this will help you avoid over or underfeeding
4. Investing time and resources into soil fertility, grazing infrastructure, grass measuring and grass budgeting for heifers can have a significant return on investment

In the period immediately following weaning, calves should remain on their starter ration until they reach approximately 10-14 weeks of age before transitioning to a grower ration (16%CP on a dry matter basis). At this point they should be consuming up to 5kg of solid feed per day, this including forage.

Appropriate post-weaning nutrition relies on supplying sufficient metabolizable protein to facilitate muscle weight gain whilst avoiding excessive energy to ensure that heifers do not become overfat as this can affect fertility. Puberty is largely linked to body weight meaning that dietary factors can affect the age at which puberty and therefore breeding occurs. However, if the aim is for heifers to calve at 24 months of age, then heifers need to reach a target weight (60 % of mature body weight) to start breeding at 13.5 months of age. Puberty can be reached any time between 8-16 months of age depending on the rate of weight gain.

However, as heifers are most fertile at the the third oestrus cycle after puberty, it is recommended to feed at a rate which will ensure puberty is reached around 8 weeks before breeding commences. If the weaning weight, breeding weight and a goal age for breeding are known then an appropriate growth rate and corresponding dietary requirements can be calculated. For example, if a heifer has a mature bodyweight of 630 kg and is weaned at 80 kg at 2 months of age, to reach 55-60% of mature bodyweight at breeding (330 - 360 kg at 13 months) she needs to gain between 0.75 -0.84 kg/day.

Dairy heifer replacements which are behind target live weight for breeding must be identified early and fed a diet containing sufficient nutrient quantities to meet maintenance energy and protein requirements in addition to supporting the correct ADG required to achieve live weight at first service. Feeding heifers to attain a live-weight gain of 0.8 kg/day is recommended. Table 10 indiates an appropriate level of nutrition to be offered to heifers gaining 0.8 kg/day.

Table 10: Diet energy and protein requirements for large-breed dairy heifers gaining 0.8kg/d (NRC, 2001)

	Heifer body weight (kg)			
	150	300	450	600
DM intake (kg/d)	4.2	7.1	11.3	13.0
Crude protein (% DM)	15.9	12.3	11.0	12.9
Rumen undegradable protein (% CP)	4.5	2.6	1.4	3.1
Rumen degragrable protein (% CP)	10.4	9.7	9.6	9.8
ME (MJ/kg)	10.25	9.54	8.70	9.67

"For example, if a heifer has a mature bodyweight of 630 kg and is weaned at 80 kg at 2 months of age, to reach 55-60% of mature bodyweight at breeding (330 - 360 kg at 13 months) she needs to gain between 0.75 -0.84 kg/day."

Feed composition

Diets which incorporate large amounts of grass or silage may be higher in CP (20-24%) but the amount consumed is relative to the supply of fermentable carbohydrates and providing a total-mixed ration is preferable. Lower quality forages can be successfully fed to heifers if target growth rates are being achieved and will improve faecal dry matter compared with more digestible diets. The amount of protein consumed is relative to the sum of rumen degradable protein (RDP) required for microbial growth and rumen undegradable protein (RUP) which supports the energy allowable average daily gain (ADG).

Studies in milking cows have shown a 4% increase in feed utilization when using a total-mixed ration (TMR) feed compared to a conventional ration of forage and grain fed separately. This is linked to a reduced incidence of digestive and metabolic disorders with a 5% increase in milk yield per lactation. It is important to monitor live weight and body condition as overfeeding at this stage can result in a reduction in milk production due to general over-fatness. Controlled or restricted diets during the prepubertal period have shown improvements in lactaction when compared with ad-lib feeding, and some studies have indicated cow lactation yields may be improved by 8-21% by using a step-feeding approach. Advancements in precision technology has led to the potential of feeding individual cow diets according to breed value, milk yield, body condition score or reproductive capacity and are being further explored by AFBI.

Grazing the dairy heifer

Grazed grass provides a high protein/low fat diet, and remains the cheapest source of high quality feed in ruminant livestock systems. Proper grass utilisation requires letting animals graze at the right time, to the right height and having the right amount of stock per area. Grass utilisation in a given grazing system can be increased by monitoring sward height and cover on a regular basis. Set stocking, in which animals have unrestricted access over a wide area requires low management input, low capital costs and can work well if sward height is managed properly. However, set stocking is generally associated with lower forage yields, uneven manure distribution, poor grass utilisation and can be difficult to maintain grass quality and sward height. Rotational grazing requires closer monitoring of forage supply and investment in fencing but can result in higher productivity since animals are moved around a number of small paddocks after a certain number of days based on sward height and cover. In a rotational system, paddocks have time to rest and recover and a more consistent sward height can be maintained which can extend the grazing season period.

In a recent AFBI study which ran between June and October, heifers aged 3-7 months were allocated to either 1) a continual grazing system, in which animals remained for the duration of the grazing season, (2) a 6-day rotation system in which animals were rotated through 6 paddocks every 6 days, and (3) a 3-day rotation system, in which animals were rotated through 12 different paddocks every 3 days. Target pre- and post-grazing sward heights were set at 2500 and 1600 kg DM/ha respectively. Heifers managed in the continuous grazing system gained 0.64 kg/day whilst rotationally grazed heifers achieved an extra 0.04 – 0.16 kg/day without concentrate supplementation. This highlights the benefits of a rotational grazing system, however it must be remembered that young animals should always be offered clean, high quality grass. If grazing in the same area as older animals, implement a leader-follower rotational system where young animals are allowed onto a paddock before the older animals as this will allow them to get the best grass and help minimise the risk of picking up gastrointestinal parasites. It is important to consider trace element status of animals at grass work with your veterinary surgeon to determine if supplementation is required.

Once a grazing system has been selected, it is also important to understand how much to offer heifers in order to meet recommended growth targets. Pasture allowance, the grazing area allocated to a group of animals, is recognised as a key factor in animal production due to its effect on herbage intake. Pasture allowance can also affect pasture utilisation and the nutritional value of the sward in subsequent rotations. A recent AFBI study

examined the impact of pasture allowance on grass utilisation and performance of young heifers. Five month old heifers were managed in a rotational grazing system and allocated to pasture allowances of either 1.8, 2.4 or 3.0 % of bodyweight between June and October. Results showed that grass utilisation decreased from 81.5 % to 67.3% as pasture allowance increased from 1.8 to 3.0% and live-weight gain increased from 0.64 to 0.82 kg/day (Table 11). A second study which investigated the effects of the providing the same pasture allowances in 18 month old in-calf heifers found similar results, with grass utilisation decreasing by 24% and live-weight gain increasing by 0.19 kg/day as pasture allowance increased from 1.8 to 3.0%. The practical conclusion from these studies was that allocating a pasture allowance in the region of 2.4% of herbage dry matter per kilo of live weight provides an optimal compromise between animal performance and grass utilisation in both pre-pubertal and in-calf heifers.

Table 11: Effect of pasture allowance on heifer live weight gain and pasture utilisation across the season

	Pasture Allocation (% of live weight)		
	1.8%	2.4%	3.0%
Post-wean heifers			
Live weight gain (kg)	0.64	0.75	0.82
Pasture Utilisation (%)	82	72	67
In-calf heifers			
Live weight gain (kg/d)	0.72	0.79	0.91
Pasture Utilisation	84	69	60

As these studies have shown, providing heifers are offered an appropriate amount of high quality grass, weight gains in the region of 0.8 kg/day can be achieved without the need for concentrate supplementation. However, as grass quality and weather conditions can vary across the grazing season, it can be difficult to achieve consistent growth. If weather and grazing conditions are poor and heifers fall behind target growth it may be necessary to provide supplementary concentrates. However, flat rate feeding of concentrates to heifers at grass can significantly increase rearing costs. New technologies are being developed which allow precision concentrate feeding of heifers at grass and have been investigated by AFBI in a recent study. Pre-pubertal heifers were managed within a rotational grazing system with a pasture allowance of 1.8% of live weight in grazed grass dry matter per day. They were allocated to receive either 1. individual concentrate supplementation based on live weight gain fed through a precision feeding performance hub; 2. concentrate supplementation fed at group level via trough; or 3. no concentrate supplementation. Offering concentrates on an individual level resulted in an overall reduction of 12 kg/head in total concentrates fed compared to group 2. By the end of the study, individual concentrate supplementation had reduced the proportion of heifers under target weight to only 19%, compared to the 43% and 86% of heifers in the group supplementation and no supplementation treatments, respectively (Table 12). This highlights the importance of monitoring animal performance throughout the grazing season as a means of improving the proportion of heifers achieving target weights in a cost effective manner.

Table 12: Effect of concentrate supplementation at grass on heifer performance and pasture utilisation

	Individual Supplementation	Group Supplementation	No Supplementation
Mean live weight (kg)	298	290	283
Average daily gain (kg/day)	1.18	1.18	0.85
Total amount of concentrate/head (kg)	106	118	0
Pasture utilisation (%)	82	86	88
% heifers under target weight at start of experiment	48	57	48
% heifers under target weight at end of experiment	19	43	86

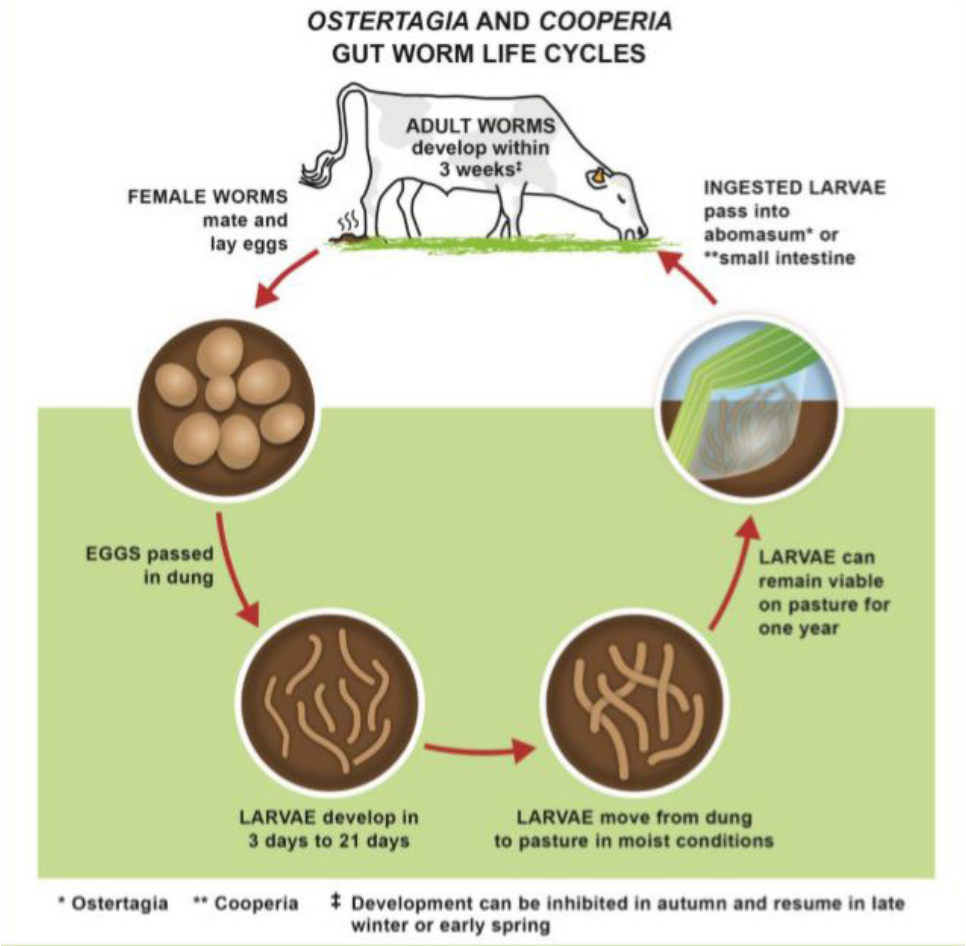
Worm Control in Calves

Gastrointestinal (GI) roundworm and fluke infections can have a considerable economic impact, as well as implications for the growth, productivity and welfare of cattle. Resistance to all classes of broad-spectrum anti-nematode anthelmintics and some flukicides have been reported. This places increased importance on implementing a control programme which uses diagnostics to inform treatment decisions, and management practices to lower contamination of the environment.

Infection with gutworms such as Ostertagia ostertagi and Cooperia oncophora (types of roundworm) causes Parasitic Gastroenteritis (PGE). This disease is most commonly found in first season grazing calves as they have not yet developed immunity and have the potential to ingest large numbers of overwintered larvae when introduced to pasture. Even when worm challenge is low, PGE can reduce growth rate in youngstock by around 30%, making it difficult to achieve target growth rates. Other signs of Ostertagia ostertagi infection can be loss of appetite, loss of body condition and scour.

Cattle do acquire immunity when exposed to roundworms, however, this can take a considerable length of time, particularly for Ostertagia ostertagi which can take up to two grazing seasons. Immunity can only develop when cattle graze pasture, however, it must be remembered that immunity is never complete and cattle of all ages can still have worms. If young calves are never exposed to pasture, for example those born in the summer in all year round calving herds, they will be parasite-naïve when they are grazed the following spring.

In order to make the most effective use of cattle wormers, it's important to work alongside your veterinary surgeon to develop a herd health plan for your farm. A number useful resources for effective control of parasites can be found via the Control Of Worms Sustainably (COWS) project website https://www.cattleparasites.org.uk. This project highlights the importance of treating the RIGHT ANIMAL, using the RIGHT PRODUCT, at the RIGHT TIME, with the RIGHT DOSE RATE in the RIGHT WAY. Additionally, using diagnostic tests such as faecal egg counts can help to provide useful information on infection burden throughout the grazing seaon.



Growth Targets

Take home messages:

1. Measure the weight of calves at birth and routinely thereafter to determine average daily gain
2. Assess weight gain against expected weight gain and where necessary implement corrective strategies to achieve successful conception by 15 months for calving at 24 months
3. Avoid over-fatness which can cause problems during calving and post-calving recovery

It is important to continue to monitor heifer development to check you are on target to achieve calving by 24 months of age. The weight gain of heifers is dependent on the net energy available for growth after the animal's maintenance requirements have been met. The energy available and the efficiency of energy utilisation are influenced by the quality of the feed (dry matter content), hormonal status of the animal, as well as external stresses such as thermal regulation, climatic conditions and animal health. Such deviations from target incur greater expense in terms of feeding and rearing at an approximate rate of £2.87 per day.

How to Measure

Measuring the growth rate of heifers gives an indirect indication of their feed conversion efficiency and measures the likelihood of achieving target growth rates. Growth is at its most efficient in the first 2 months of life so high growth rates should be targeted during milk feeding. Added benefits of monitoring growth include identification of underperforming calves or suboptimal conditions. Results can be used to estimate cost efficiency and manage the rate of gain. AFBI conducted a survey where farmers were asked to estimate the weight of their animals visually for comparison to the actual live weight and found a large range in the accuracy of visual estimation (Table 13) which lead to delayed breeding with average age at calving of 29 months.

Table 13: Visual perception of body weight compared to accurate full body weight recorded using electronic scales

Development Stage	Target weight for age (kg)	Farmer estimated weight (kg)	Actual live weight (kg)	Percentage difference (%)
Weaning	92	85	96	-7.1
Breeding	433	378	438	-11.2
Calving	580	555	585	-3.8

Electronic scales are the most accurate method of determining weight and can be used in combination with a feed stall or crush. Half body scales have been compared to full body scales with a high correlation and may be easier to install to regularly capture weight within the pen. In field weighing can be incorporated using portable scales or an AFBI developed weigh band which can be used when placed flat against the skin around the chest of the heifer between its front leg and shoulder blade. Although not as accurate at predicting weight, height can be measured when the calf is standing on a hard level surface by taking measurements across the withers or rump and this can be used to provide a quantitative measure of development.

Growth Rate

Heifer growth rates must be planned and monitored through the rearing period to achieve required targets. Bodyweight as a percentage of herd adult weight is the best indicator and driver of puberty and therefore linked to age at first service. At least two measurements are required to determine growth rate. The weight of the calf at birth should be recorded to establish the baseline for average daily gain. It is best practice to record the weight of the calf at weaning and again at 6 months and 12 months of age to check the distance from target and apply corrective measures where necessary. This permits time to intervene prior to breeding to achieve conception by 15 months of age and calving within 24 months. Growth rates of 0.7 - 0.8kg per day are recommended during first pregnancy to achieve good body condition at calving. The key here is to maximise weight gain without accruing over-fat heifers and is best estimated against % mature body weight as outlined in Table 14.

Table 14: Example weight for age targets within a 24 month age at first calving rearing programme based on a mature Holstein cow weight of 630 kg

Age (month)	Weight (kg)	Daily weight gain (kg/day)	Weight as percentage of mature weight (%)
0 (birth)	40		
3	107	0.78	17%
6	170	0.77	27%
14	347	0.77	55%
24 (pre-calving)	567	0.77	90%

Benchmarking Tools

AFBI have developed growth monitoring tools such as BovIS to enable farmers to assess their animals growth against predicted targets. The information is derived from APHIS and provides estimations from birth to slaughter as shown in Figure 17.

Figure 17: BovIS Growth Monitoring Tool

"Heifer growth rates must be planned and monitored through the rearing period to achieve required targets. Bodyweight as a percentage of herd adult weight is the best indicator and driver of puberty and therefore linked to age at first service."

Calf Housing

Take home messages:

1. Growth rate can be dramatically reduced in sub-optimal temperatures
2. Calf housing must provide adequate temperature, humidity and ventilation to reduce disease risk
3. Good hygiene practices are essential
4. Less than 10% of calf houses monitored in a recent AFBI survey had competent ventilation

The environment in which the calf is reared not only impacts on the risk of calf mortality, ill health and potential lifetime performance but also on the efficiency in which feed is converted to growth. To promote calf performance and minimise the incidence and spread of disease, calf housing design must consider the impact of draughts, humidity levels, stocking density and drainage. Farmer convenience and ease of best practice implementation must also be considered in housing design.

Temperature, humidity, air speed and light

Under low ambient temperatures calves require more energy derived from feed to maintain normal body temperature (see Table 8). Low temperatures coupled with low or moderate levels of nutrition can negatively impact on the calf's immune systems resulting in increased risk of calf ill health. High levels of humidity often caused by poor pen drainage, wet bedding, leaking roofs/pipes/gutters and inadequate ventilation will add to the
challenge. Not only do the pathogens in the air survive better in humid conditions but the increased moisture will add to the chill effect on the calf at lower temperatures. Similarly, draughts at calf level will further chill the calf. However, it is important that the air within the house is replaced 4-6 times per hour to reduce the risk of respiratory problems. Effective housing design coupled with management can address all these issues. Some key requirements for a successful calf house are outlined below:

Pen Allocation

The area of the individual stall/pen for a calf from birth to 8 weeks of age must be at least 1.5m^2 and the width at least equal to the height at withers. There is commercial pressure to stop housing calves individually, and keep calves in pairs and then group calves to gain benefits of increased feed intakes and better socialisation. It is safer in terms of disease management to limit the number of calves in any group and restrict the age range within any one pen.

Pen design

Pen design should allow at least visual contact between calves, and importantly be easy to clean. The recent AFBI Optihouse survey of farms indicates that frequency of cleaning is too low on many farms, with lack of time to clean and/or pen materials that are difficult to clean being part of the problem. Plastic pens for single calves have the simplicity of being removable from the calf building for powerwashing, disinfection and drying. A pen floor should have a minimum slope of 1 in 60 to permit effective drainage after cleaning, and an optimum 1 in 20 slope for drainage under straw bedding. Channel drains set into the floor with/without simple steel covers should be used to collect urine/dirty water from the front of pens to keep passage floors clean and dry.

Group pens have benefits for calves and for labour, but increase some of the risks of spreading pathogens. Group housing of young calves increases the requirement for competent hygiene, at floor level, and especially of feeders and drinkers.

Calf Housing

The design requirements of any livestock building are:

- Good hygiene ; the ability to be efficiently and effectively cleaned
- Good drainage
- Fresh air delivery: natural ventilation, with competent inlets and outlets, and mechanical help if needed
- Moisture control; sloped floors, good drainage, control of leakages, good ventilation
- Air speed control; fresh air is an essential requirement for good health but draughts must be avoided at calf level

Ventilation is a prime requirement of livestock production, with the aim to introduce fresh air throughout an animal house and to remove exhaust air and moisture without exposing stock to draughts. The value of fresh air delivery is that it not only picks up aerial contaminants such as dusts, fungal spores, gases, and airborne pathogens (germs), but also because fresh air is an excellent biocide. Fresh air kills airborne bacteria and viruses 10-20 times quicker than stale air.

Competent ventilation is also a key component of managing moisture in livestock buildings, along with floor and drain design. Active ventilation will constantly remove moisture that is emitted by stock and from damp surfaces, and helps to keep stock comfortable, reduce straw costs, and provide a healthy environment. In passive ventilation systems, when the wind stops or is prevented from driving a ventilation system, moisture levels inside a calf house will rise.

The Optihouse project has applied proven science to the description of ventilation and air movement in Northern Ireland dairy units. The results show that approximately 10% of farms have ventilation systems capable of sustained delivery of competent ventilation, with 30% compromised and over 50% as having significant failure of inlets, or outlets, or both. The power to drive ventilation for naturally ventilated livestock buildings is mostly provided by the wind, which is variable and comes from all points of the compass at some time during the year. There is also a small but predictable amount of time per year when the wind speed is too low or 'calm' to move any air, at which point natural ventilation will cease in all calf houses.

Therefore the base elements of any calf house ventilation are:

- The degree of exposure of the calf house to the weather, on all sides
- The area of air inlet in the sidewalls, relevant to the number of calves housed
- The area of outlet in the roof, relevant to the number of calves housed and the slope of the roof
- The extent to which all calves in the building are provided with clean air
- The balance between fresh air delivery and a draught at animal height

Improving the delivery of fresh air and removal of airborne contaminants is a major target for all livestock units, particularly calf and youngstock buildings. They are the most vulnerable animals on any farm and also represent the best point at which to invest in the productive future of the herd. A simple method for calculating inlet and outlet areas for naturally ventilated cattle buildings can be found on pages 15-21 in https://ahdb.org.uk/knowledge-library/brp-better-cattle-housing-design.

The main design improvements for ventilation in calf housing are:

- Replacing solid sidewalls with cladding that lets air through but not rainwater
- Spacing existing sheeting from sidewalls to provide protected inlets
- Inlet designs and protection of doorways and outdoor hutches to manage draughts
- Competent ridge designs
- Using fan and duct systems to guarantee 24/7 fresh air delivery
- Use of simple louvres in existing openings in traditional buildings

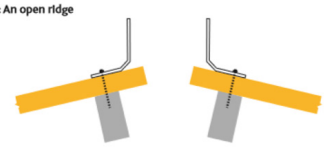
Cladding materials

No air gets through a solid wall. Air coming in from an adjacent air space containing other cattle does not provide fresh air. Both situations contribute significantly to increased risk of respiratory disease, so that location of a calf house within the farm complex will have an impact on calf health through ventilation. Solid cladding above animal height can be replaced with porous cladding as long as air movement is directed away from youngstock, and rainwater ingress is prevented. For small buildings with low numbers of stock perforated sheeting on the sidewalls may be adequate, or Yorkshire boarding. Space boarding is specified too often, and does not control rainwater ingress or air speed. Where calves are housed in traditional stone walled buildings with only doors and small windows as apertures in the walls, it can be difficult to give a sufficient area of inlet without creating large holes that create draughts. One solution is to fit louvres into window openings so that all incoming air is directed above the calves.

Ridge designs

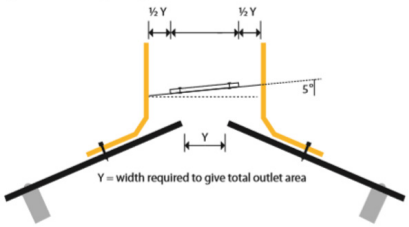
All competent livestock buildings need an outlet in the roof to allow warm, stale air to leave the building. This is especially vital when wind speeds drop or in areas where the wind is not able to ventilate a space, as warm air will rise through available holes in the roof to be replaced by an equal volume of air from outside the space. This is natural stack effect ventilation.

Figure 5: An open ridge



The design of the outlet in the roof is simple but easily got wrong. There is an absolute need for approximately 0.04m^2 of outlet in the roof per calf housed, and this can be achieved by opening existing rooflights in old buildings, or removing the existing ridge cap. The important design detail is the 'cover' for the ridge. The use of a cap above the open ridge significantly reduces the efficiency of house ventilation compared with the use of upstands to protect the ridge. The reason for this significant difference is that as the wind blows across the upstand a negative pressure is generated, sucking stale air out of the building. In comparison wind blowing across a cap above an open ridge generates a positive pressure, blowing air into the building, preventing the stacking effect needed for passive ventilation systems.

Figure 6: A covered open ridge



Ventilation systems

Where walls do not allow sufficient ingress of fresh air, and in order to provide ventilation during the critical periods of damp, calm weather, a fan and duct ventilation system should be fitted. An extractor fan system should only be used in buildings of small volume and with only a small number of inlets in the walls. A positive pressure fan without a duct, that blows air into a space, is not suitable because the stream of air will spread dampness and pathogens from animal to animal along the trajectory of the fan stream.

Fan and duct ventilation systems are low cost to buy and run, and mean that the difficulties of providing fresh air to all corners of a building can be overcome easily. Over 10% of farms in the Optihouse survey are using fan and duct systems, but most other farms would benefit from similar systems.

A competent system requires information on:

- The practical height of the tube above pen level, and distance from the front & back of the main pens
- Knowledge of fan capacity, tube diameter, and size and location of the holes in the tube for the site
- A designed outlet in the roof; otherwise dirty air will be shared at animal level

Floors and drains

There is a considerable amount of liquid produced in a calf building, and if it is not managed it will cause problems. Many pathogens that cause problems in livestock systems survive best in damp conditions, which makes dryness a target for good hygiene. Dampness also makes cold air temperatures feel colder, adding to potential problems for young calves. Dampness increases straw use and therefore bedding costs and predisposes calves to being dirty. Floors that do not drain correctly will never improve until active interventions are made:

- Use sawdust in problem areas
- Cut channels into concrete floors and cast drainage channels 75-100mm wide
- Eliminate unnecessary water loss form drinkers, pipework, roofs, gutters and downpipes
- Eliminate water ingress at floor level
- For a long-term solution, cast a new concrete floor on top of the old with integral slope and gutters

The target for calf housing is to have calves on a dry bed and all exposed floors dry.

Blueprint Design

AFBI are currently investigating the design of the calf house to increase the efficiency of feed, labour and livestock use within calf rearing enterprises in Northern Ireland. The aim is to enhance understanding of calf rearing houses within Northern Ireland and the key factors linked to poor environmental conditions, failure to deliver expected growth and excessive labour requirements. A better understanding of the impacts and interactions between level/type of calf nutrition, bedding, calf grouping and environmental conditions will help inform best practice and refine calf rationing systems to better reflect performance under a range of environmental conditions.

The development and quantification of benefits of independently and robustly proven fixes to existing common calf house designs and rearing systems in Northern Ireland will be evaluated. Through these 'fixes' producers will provide more favourable environmental conditions to allow high levels of calf health and performance with maximum labour efficiency. The outcome will be development of blueprints for new modern calf rearing housing that would maximise delivery on both calf and producer considerations. Calf considerations include air quality, social interactions, growth performance, space allowance etc. Producer considerations include, labour efficiency and flexibility, scalability, cost to build and run, integration within the farmyard, degree of mechanisation etc. The range of blueprints would be developed to suit the climatic and production system variations within Northern Ireland.

Click the following link for more information on the Optihouse project and go to AHDB Dairy's Youtube Channel for more videos on housing design and house hygiene

Appendix 1: How is my herd performing

A key performance indicator (KPI) is a measure of performance calculated from farm data to identify the unit's strengths and weaknesses. Depending on your system KPIs can be calculated for each batch of calves or for the total number of calves reared throughout the year. The following KPIs, produced by AHDB, have been identified for assessment of calf rearing units (Source: https://beefandlamb.ahdb.org.uk/wp-content/uploads/2017/09/Calf-rearing-notebook.pdf)

KPI	Definition	Example	Target
Calf live weight at weaning (kg)	Average calf weight at weaning (kg)	85 kg	Double birth weight
Daily live weight gain to weaning (kg/day) KPI specific for dairy herds	(Average calf weight at weaning (kg) – birth weight (kg))/ Average calf age at weaning (days)	(85-40) / 56 = 0.8 kg/day	>0.7 kg/day
Daily live weight gain to weaning (kg/day) KPI specific for specialist calf rearers	(Average calf weight at weaning (kg) – purchase weight (kg))/ Average days on unit prior to weaning (days)	(85-55) / 40 = 0.75 kg/day	>0.7 kg/day
Daily live weight gain post weaning (kg/day)	(Average calf weight (kg) – weaning weight (kg)) / (Average calf age – Average weaning age (days))	(137-85) / (98-56) = 1.2 kg/day	>1 kg/day
Calf Mortality (%) For dairy producers it is useful to split this KPI into deaths before 24 hours and those after	(Number of calf deaths / Number of calves born or purchased) x 100	(1/60) x 100 = 1.6%	<2%
Incidence of pneumonia (%)	(Number of calves with pneumonia / Number of calves born and purchased) x 100	(5/40) x 100 = 12.5%	<15%
Incidence of scours (%)	(Number of calves with scour / Number of calves born and purchased) x 100	(4/40) x 100 = 10%	<10%

Appendix 2: Management Notes

As highlighted throughout the booklet, providing calves with good quality colostrum and paying close attention to calf house hygiene is really important to ensure that calves meet their potential. Within this section are some tips on calf management, testing colostrum quality (adapted from AHDB Dairy; Calf Management: A practical guide to rearing healthy calves), and an example guide to maintaining hygiene in the calf house.

Area	Management points
Calving pen hygiene	• Significant source of infection risk for the calf. • Calving pen to be cleaned thoroughly (with straw removed and power washed) as often as possible during the calving season. During infrequent calving, wash using disinfectant. • Pen must be bedded with fresh straw for each new use. • Calves should spend a limited amount of time in the calving pen before their re moval to reduce infection risks. Calves should be moved to individual calf pens.
After birth	• Treat calf's umbilicus with iodine as soon as possible. This is to prevent infection. • Calf to be fed colostrum as soon as possible after birth. • Attach Calf ID tag.
Colostrum Management	• Calves should get their own dam's colostrum as soon as possible (With the exception of Johnes flagged cows*) • Clean colostrum minimizes the risk of infection to the calf. Therefore: - Teats of each cow must be cleaned with antiseptic wipes prior to colostrum collection. • Milking unit should be clean before use and sterilized after use. If milking by hand wear disposable gloves. • Calves should receive 3-4 L (10% of birth weight) of their dam's colostrum within hours of birth. If stomach tubing it may be advisable to provide 3L within 2 hours of birth. • If the calf can't suckle the full quantity of colostrum it should receive the rest via a clean stomach tube. • If the dam produces less than 2L, the calf should be supplemented with colostrum replacer for its first feed. • Colostrum replacer must be used for calves born to dams that are flagged with known health problems (eg: Johnes). • Colostrum dump buckets should be thoroughly cleaned and disinfected between each collection. • Colostrum should be fed within an hour of collection otherwise it should be refrigerated for up to 24 hours in a sealed container prior to use. • Stored colostrum should be warmed to 38°C in a water bath prior to feeding. Colostrum should never be microwaved. • Colostrum quality should be tested using the first milk collected using a refractometer or colostrometer. Readings of 21.0% or less using a BRIX refractometer, or colostrometer readings of less than 20mg/ml of Immunoglobulin indicate poor quality colostrum.

Johnes flagged cows*	• Cows with possible Johnes association should be easily identifiable within the herd. • These cows should be calved in a separate calving pen. • Calves should be removed before they have any chance to suckle from their dam. Calves to be fed colostrum replacer.
Individual Calf Pens	• High hygiene standards should be maintained throughout the calving season. • Fresh straw bedding should be provided for each newborn calf entering the pen. • Pens should be power washed and disinfected weekly. • Keeping clear records of D.O.B., body weight at birth, any birthing difficulties, information regarding the calf's first feed (time, volume, feeding method, use of colostrum replacer etc.) are essential. • Once dry, calves can be fitted with a clean, dry calf jacket.
Group Pens	• Calves should be moved to group pens with calves of similar age. (All calves should be grouped at no later than 8 weeks of age) • Group pens should be thoroughly cleaned and disinfected between groups of calves. • Pens should be cleaned every 3-4 weeks. This should include the removal of straw, faeces, and any build up within the pen. • Pens should be rebedded with enough fresh straw regularly to allow for calves to nest. • Calves should be provided ad lib access to fresh, clean water at all times.

Testing colostrum quality

Using a colostrometer

Equipment:

- Clean colostrometer
- Measuring cylinder
- Colostrum (at room temperature)

REMEMBER:

- The Colostrometer should be examined for cracks or breaks in the glass before each testing.
- It is essential all equipment is clean, no visual dirt, contamination (from manure etc.).
- Colostrum should be tested at room temperature. Colostrum shouldn't be tested direct from the refrigerator or the dam.

Procedure:

1. Colostrum should be poured in a clean measuring cylinder. There should be no froth on the colostrum.
2. Place the colostrometer in the sample with the scale end pointing upwards. Allow the colostrometer to float in the in the colostrum sample for 1 minute before taking a reading.
3. Read the value from the point where the colostrometer is floating at the surface of the colostrum.

Is the colostrum of sufficient quality?

- Readings of more than 50mg/ml of Immunoglobulin (Green zone) indicate good quality colostrum. This colostrum can be used or stored appropriately.
- Readings of less than 20mg/ml of Immunoglobulin (Red zone) indicate poor quality colostrum. This should be discarded.
- Readings between 20-50mg/ml of Immunoglobulin (Yellow Zone) indicate marginal quality of the colostrum. Remember that the recommended target is for the calf to receive 150g IgG in a maximum volume of 4L colostrum in its first feed – consider if this is possible before making the decision to use or store colostrum of marginal quality.

Using a Brix refractometer

Equipment:

- Refractometer
- Distilled water
- Clean cloth
- Colostrum (at room temperature)

Remember, before each use:

- Ensure device is free from dirt and debris. Ensure no cracks or damage it the prism.
- Calibrate the device (in accordance to the instruction manual) using distilled water on the prism to give a reading of 0.0.
- Clean the prism thoroughly between samples to help ensure accuracy of readings

Procedure:

1. Clean the surface once calibrated so the prism is dry.
2. Fill the prism with the colostrum sample.
3. Take your reading from the refractometer: this indicates the quality of the colostrum.
4. Readings under 22.0(%) are of poor quality colostrum and should be discarded.

Cleaning and disinfecting of calf pens

Cleaning and disinfection of calf housing should take place at the beginning and end of each calving season, and during periods of disease outbreak. Individual pens should be cleaned for each new calf and group pens should be cleaned as soon as all calves are weaned and removed from the pen. Cleaning out the buildup of bedding and faeces every 3-4 weeks, rather than rebedding and topping up straw, limits exposure to disease, and poor hygiene levels within the pens. All animals should be removed from the calf housing area before commencing with a deep clean.

Equipment:

- Waterproof/protective clothing
- Gloves
- Facemask
- Safety glasses/goggles

Pens & Bedding:

- Clear all straw and bedding using the appropriate tools available (Telehandler/other agricultural vehicle) and dispose.
- Depending on the housing system, it may be necessary to remove beams and weigh cells around feed systems to clean underneath and around the area.
- Affixing plastic wrap around all feed equipment/computer stations/electric points is a useful way to seal equipment against water exposure.
- Brush each pen and gently hose down with (preferably) lukewarm water to clear areas and remove debris. Ensure all channels and gullies are clear.
- Apply a chlorine detergent and scrub down with a long handled brush.
- With, preferably hot (60+°C), water, rinse the detergent off all pens and floors with a power hose.
- Allow to air dry.

Disinfecting areas:

- Apply disinfectant of choice across all pen floors, walls, and around feeding equipment. It is a good idea to discuss which disinfectant is needed with your veterinary surgeon.
- Allow to air dry.
- Remove plastic wrap and re-assemble pens prior to new calves entering.

Routine cleaning of calf house equipment

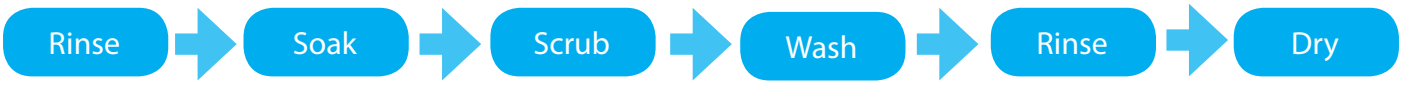
Regular cleaning of equipment prevents calves picking up infections from contaminated surfaces such as feeding equipment. Good hygiene prevents transfer of disease between animals/ animal groups.
This procedure applies to equipment that should be cleaned on a daily basis/between uses such as: Stomach feeding tubes, colostrum dump buckets, milk bottles, teated buckets, feed buckets.

Equipment:

- Long waterproof gloves
- Waterproof protective clothing
- Running water/hose
- Sink scrubbing brush
- Chlorine detergent and Acid Sanitiser
- Eye protection
- Brush

Procedure:

1. Rinse with warm water (<40°C) to remove all dirt and milk residues.
2. Soak in hot water (55-60°C) with chlorinated detergent solution for 30 minutes.
3. Drain and scrub all surfaces with a brush.
4. Wash in warm water (<50°C) to remove any residues.
5. Rinse with an acid sanitizer (as per manufacturer's instructions) to prevent bacterial growth.
6. Allow equipment to air dry on a drying rack. Not by placing on the floor.



Calf Jackets should be washed between each calf use following manufacturer's instructions. Jackets should be washed in mild detergent at 60°C. Jackets should be fully air dried before next use.

Appendix 3

Example Recording Sheets

This section provides examples of how calf birth and health information can be recorded (adapted from AHDB Source: https://beefandlamb.ahdb.org.uk/wp-content/uploads/2017/09/Calf-rearing-note-book.pdf)

Calf and Colostrum Intake record

Calf Tag	DOB	Sex	Birthweight (kg)	Dam ID	Sire ID & Breed		Colostrum Volume & timing of feed	Colostrum Quality
1234-1	30-09-19	F	40	0834-2	ROCKSTAR/ HOL	1st	Tubed 3 litre @ 8am	32 on Brix
						2nd		
						1st		
						2nd		
						1st		
						2nd		
						1st		
						2nd		

Protocol for standard treatments

Below is an example of what treatment you may choose to give to a calf exhibiting signs of scour, however, it is important to develop your own treatment protocols for specific illness with your veterinary surgeon

Disease or condition	Signs to look for		Treatment
Scour	Loose faeces, dirty hind-quarters, possible high temperature	Option 1	Oral rehydration therapy between feeds, isolate if in a group pen
		Option 2	As above plus antibiotic treatment daily for 3 days and addition of an anti-inflammatory if high temperature (>39.5°C)
		Option 1	
		Option 2	
		Option 1	
		Option 1	
		Option 1	
		Option 2	

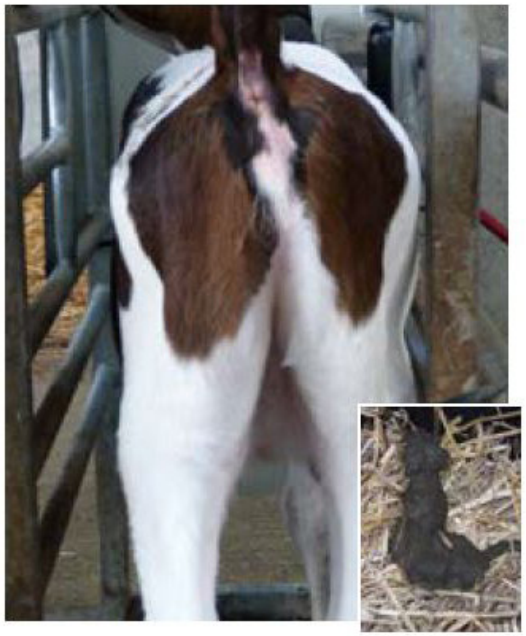
Medicine records

Date	Calf ID	Symptoms	Temperature (°C)	Drug Used	Quantity (ml)	Drug Batch Number	Adiminstered by
10-10-19	1234-1	Loose faeces	38.6	Electrolytes	2 litres	987654-3	GS

RESPIRATORY

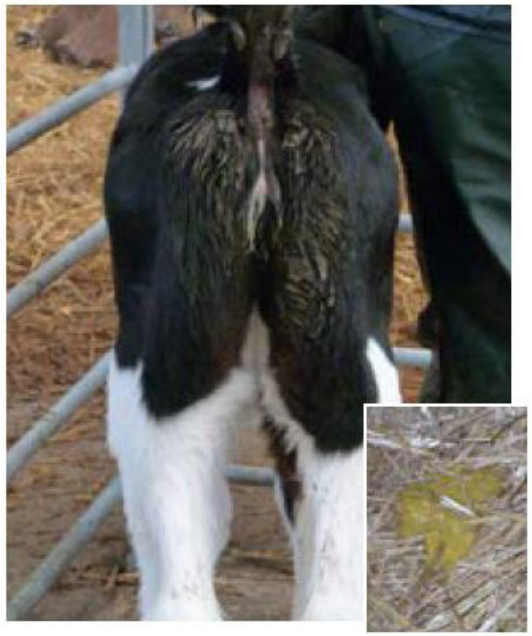
Signs of good health and vigour	Look for early signs of disease	Late signs of disease
• Bright • Playful • Curious • Keen to drink milk	• Quiet • Slow to stand • Still drinking milk	• Dull • Reluctant to stand unaided • Off milk

• Clear eyes and nose • No cough	• Discharge from eyes and nose • Cough on movement	• Severe discharge with pus • Frequent coughing/wheezing
Normal temperature (38–39°C or 100–102°F)	High temperature (>30.5°C or 103°F)	High temperature (>39.5°C or 103° F)



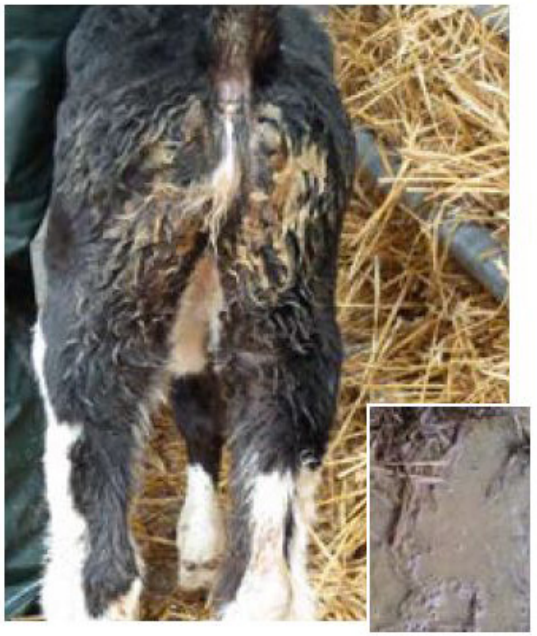
- *Clean hindquarters*
- *Well formed faeces*

Normal temperature
(38–39 °C or 100–102 °F)



- *Dirty hindquarters*
- *Loose faeces*

Variable temperature



- *Wet hindquarters* • *Hair loss*
- *Dehydrated* • *Watery faeces*

Variable temperature

ACT NOW

Implement the treatment plan agreed with your vet

Information supplied by Volac.

Appendix 4

Housing Space Allowances

Outlined below are requirements and guidance relating to livestock housing and space allowances (Source: Red Tractor Assurance for Farms – Dairy Standards 2017).

Group/Loose Housing systems

Group housing systems must be of sufficient size to enable all cattle to; lie down simultaneously, ruminate, rise, turn around and stretch without difficulty. Recommended space allowances for calves and growing youngstock are outlined below.

		Space allowance (m^2 per head)		
	Liveweight (kg)		Soild Floors	Fully Slatted Floors
		Bedded	Total (inc. bedding, feeding/loafing)	
Calves	50-84		1.5	Non-slatted lying areas MUST be provided
	85-140		1.8	
	140-200		2.4	
Growing/ Finishing/ Young-stock**	200-299	2.0	3.0	1.1
	300-399	2.75	3.95	1.5
	400-499	3.5	4.9	1.8
	500-599	4.25	5.85	2.1
	600-699	5.0	6.8	2.3

** In-calf heifers must also have access to a non-slatted lying area

Individual Calf Pens

As advised in the Red Tractor Assurance for Farms – Dairy Standards (2017), calves housed in individual pens or hutches (except for those in isolation) must have the opportunity to have direct visual and tactile contact with other calves. In terms of space allowance, they must be able to stand up, lie down, turn around, stretch and groom. Recommended minimum dimensions are indicated in the table below.

Calf liveweight (kg)	Pen size per calf
<60	1m x 1.5 m
60-80	1m x 1.8 m

Large Park
Hillsborough
County Down
Northern Ireland
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