Dairy Research Partnership review

2022

DAIRY

Contents

Photography credits

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Foreword

AHDB dairy research and development: Your levy, your future

Welcome to the latest edition of AHDB's Dairy Research Partnership Review. Firstly, many thanks to all our collaborators for some fantastic research that will support our dairy industry in maintaining its position as a global leader in the sector. Despite the challenges of the last year, it is great to see the advances in dairy genetics, husbandry and management outlined in this review. The challenges have never been greater, and it is wonderful to see that the response to those challenges has delivered even greater results, despite difficult circumstances.

For our industry to remain resilient, dairy producers must be able to evaluate and apply appropriate research and technologies on their farms. There is a huge amount of information to synthesise and to work out how and if it should be applied on farm. AHDB not only leads on funding and influencing that research but also evaluates and summarises the evidence, enabling faster and more appropriate uptake of new technologies. This is what keeps our dairy industry at the forefront of global dairy production.

The dairy cow continues to evolve genetically, and we must ensure that modern production methods improve, and not just maintain, the health and welfare of our cows. This is core to our work, and we are continually striving to ensure our measures of genetics, health, and welfare are robust. It is vital that we are able to show that changes made on farm result in improvements in health and welfare as well as improve business and environmental resilience.

The challenges to our industry will continue to change, and having an agile and forward-thinking team of highly skilled researchers is key to staying ahead. We continue to build relationships with other researchers and organisations to allow us to capture a wider range of research. This year we have worked collaboratively with the relatively new group, Ruminant Health and Welfare, and recently launched a joint call on Endemic Diseases of Livestock with the Biotechnology and Biological Sciences Research Council (BBSRC). These initiatives mean we are able to influence research and enhance the funding of research through collaboration. Our international collaborations are important, and we are working hard to ensure that we maintain those relationships. Many of our research areas do not respect country boundaries, and working with colleagues across the nations of GB is vital to ensuring we maximise the outputs of our work. This will become increasingly important when devolved nations outline their own priorities for their dairy sectors. However, I believe that this provides a great opportunity for the sector to build on the experiences of our nations and come together for the benefit of the entire sector.

Who knows what challenges will come our way next year, but one thing for sure is that our team at AHDB is well placed and ready to take on those challenges head first. The outputs of this review demonstrate that. My thanks to all involved.

Mandy Nevel
Head of Animal Health and Welfare

EnviroCow and HealthyCow genetic indices

Genetics can provide significant and permanent improvements to many industry challenges. As more data is recorded on UK farms, an ever-growing list of valuable genetic indexes are introduced.

HealthyCow

HealthyCow is a genetic index developed by AHDB to ensure that genetics can be improved for health, alongside production and efficiency. The aim of the HealthyCow index is to aid in finding bulls that will breed more fertile, healthier cows that have the ability to stay in the herd for longer.

The HealthyCow index is a sub-index of the Profitable Lifetime Index (£PLI) and is intended to be used as a secondary filter. The HealthyCow index considers:

- Lifespan
- Calf survival
- Fertility
- Somatic cell count (SCC)
- Mastitis
- Functional type
- Lameness
- Calving ease

EnviroCow

EnviroCow is the first independent genetic index to focus on breeding cows for the environmental efficiency of milk production.

The genetic index, developed by AHDB and launched in August 2021, reflects the important part genetics and breeding play in improving the environmental efficiency of milk production. The EnviroCow index incorporates:

- Cow lifespan
- Milk production
- Fertility
- Feed Advantage index (a genetic index focusing on feed conversion ability)

Marco Winters, Head of Animal Genetics for AHDB, says: “The environmental focus of EnviroCow reflects the important role cattle breeding can play in helping the farming industry reach its goal of net-zero greenhouse gas emissions. We know from past performance that genetic selection can play a significant part in improving dairy cow efficiency.”

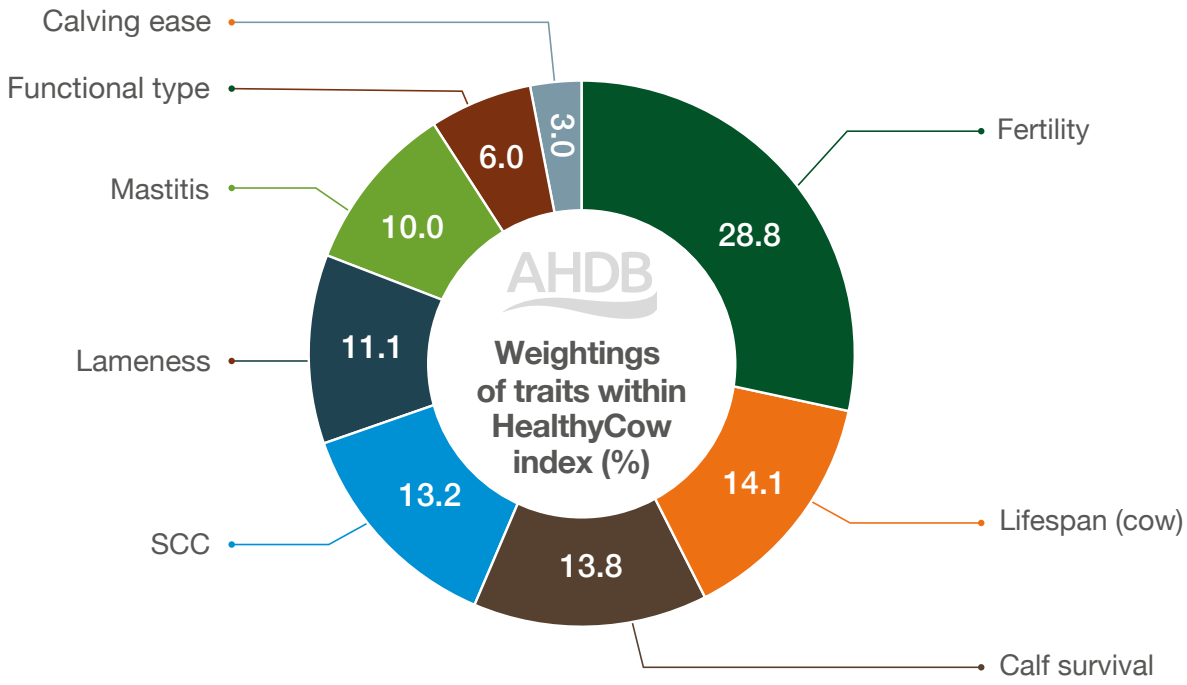


Figure 1. The percentage weightings of traits within the HealthyCow index

Using MIR to predict pregnancy and TB

Scott Denholm and Mike Coffey, Scotland's Rural College

Key messages

- Milk spectra is a by-product of routine milk recording and may be used to predict new phenotypes
- Physiological processes in the cow may leave a signature in the milk that can be detected
- Deep learning can be applied to find those signatures, thereby offering a cost-effective and non-invasive method of creating new phenotypes

Background

Around half of all UK dairy cows are milk recorded routinely. The process involves the use of a machine that shines light through a milk sample and collects the reflected light in a certain wavelength range, called mid-infrared spectroscopy (MIR). This is used to accurately predict the fat and protein content of the milk. This study was done to see what else we could predict from the same milk sample and spectral data.

Aims of the study

Using the already collected milk sample and spectral data, this project aimed to predict other important phenotypes for the same cows. It focused on TB and pregnancy because they are extremely important traits, and in regards to the analysis, they are both categorical traits – a cow is either pregnant or not or has TB or not. The signal in milk might vary in its intensity, but the status of the cow does not. This data type lends itself well to deep learning (a subset of machine learning), and the aim was to predict the status of cows in real time at each monthly milk recording. In the case of pregnancy, the loss of pregnancy late in lactation was the aim, and for TB, it was to have an additional early detection option.

What we did

We used deep learning to train models using milk spectral data from National Milk Records (NMR) and pregnancy data from NMR and TB data from Defra. Those models were cross-validated by removing data from model development and then predicting status for those records for which we knew the status already but had not been used in model development.

Results

Bot models achieved an accuracy of prediction using existing data of over 90%. Both models are now being field trialled by NMR with Defra funding to determine their accuracy in real time.

Outcomes

The conclusion is that deep learning can successfully produce highly predictive models that can form the basis of a commercial service. The use of that service by farmers could a) rapidly identify cows that have lost a pregnancy, thereby allowing timely remedial management actions and b) alert the farmer to cows that may have come into contact with TB on a monthly basis using routine milk recording data thereby allowing the possibility of reducing within-herd spread by early isolation.

Extra information

This work has been published in the Journal of Dairy Science:

- Brand et al. (2021). *Predicting pregnancy status from mid-infrared spectroscopy in dairy cow milk using deep learning.* Journal of Dairy Science.
- Denholm et al. (2020). *Predicting bovine tuberculosis status of dairy cows from mid-infrared spectral data of milk using deep learning.* Journal of Dairy Science.

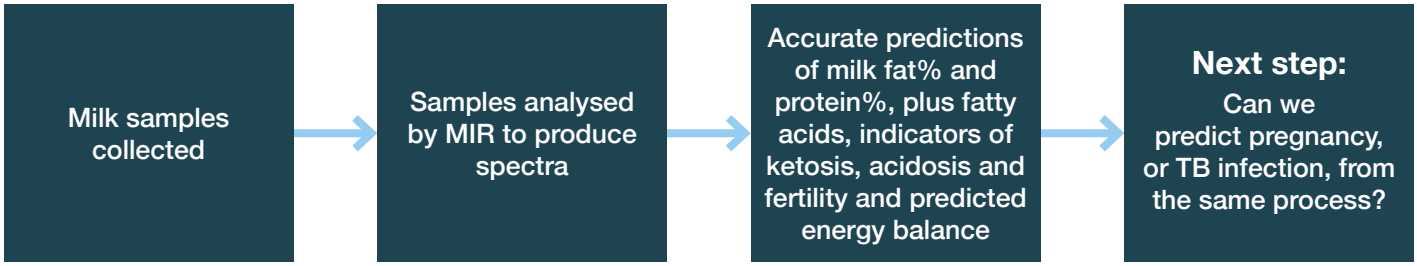


Figure 2. Process of predicting pregnancy or TB infection from milk sample MIRs

Economic return from improving genetics

Tim Harper, Promar International

Key messages

- The economic value of the UK's chief breeding index Profitable Lifetime Index (£PLI) is worth £1.58 in Genetically Influenced Margin for every point of £PLI
- For a typical 150-cow, top 25% £PLI herd that equates to an additional margin of £30,573 per year
- Assuming there is no relationship between genetics and any other costs, this will translate directly through to pre-tax profit

Background

Previous analysis had been carried out (both in 2007 and 2011) to analyse the relationship between dairy genetics and performance, using both technical and financial metrics.

The two key reasons for conducting the analysis were:

- To provide supportive data to help with the development of composite genetic indices, particularly PLI
- To demonstrate the relationship between such indices and technical and financial performance, using fully reconciled data taken from Promar's Farm Business Accounts (FBA) service

Aims of the study

The aims of the latest study were:

- To update the analysis of the value of PLI using the latest genetic, financial and technical data
- To provide an analysis of the component parts of PLI together with other proposed composite genetic indices, using a combination of technical and financial metrics

What we did

The project involved linking milk recording data with data from FBA for the same farms and running statistical analysis on the relationships between them. The analysis included 410 herds and over 104,000 cows. The farms within the analysis are nearly entirely all-year-round calving, with the balance having split block-calving herds.

Prior to the first study, Promar and AHDB agreed on a definition of the financial metrics influenced by genetics, referred to as Genetically Influenced Margin (GIM). This was again used as the composite metric for financial performance.

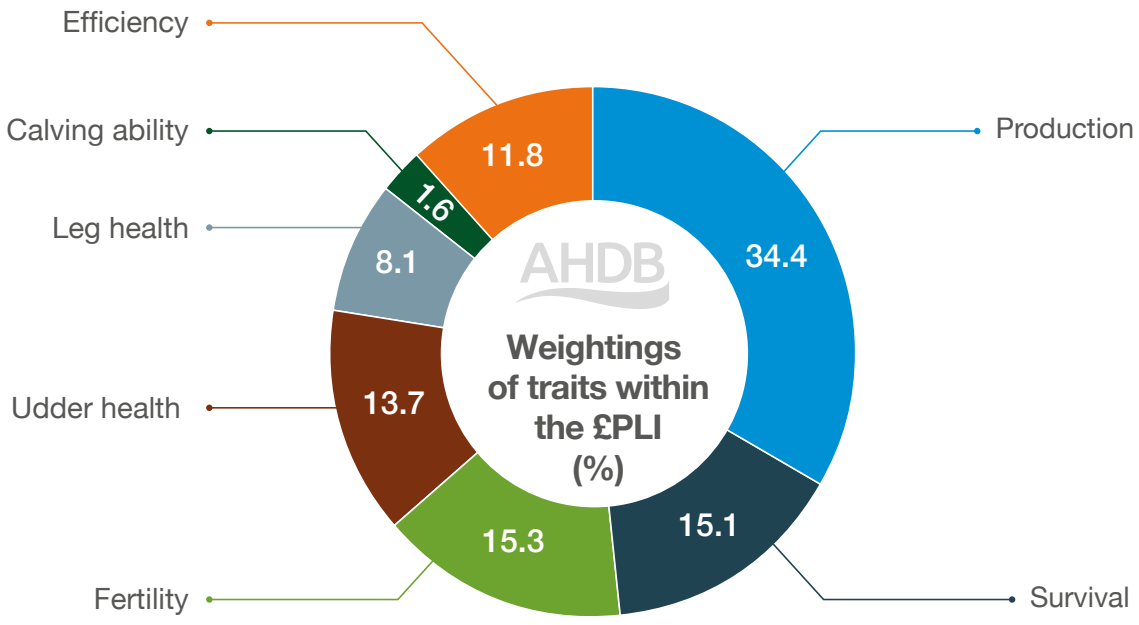


Figure 3. The percentage weightings of traits within the £PLI

Results

The economic value of the £PLI is worth £1.58 in GIM for every point of £PLI.

The results grouped by PLI are summarised in Table 1.

Outcomes

The analysis shows that herds with better genetics, as measured by PLI, generate higher margins per cow. Assuming there is no relationship between PLI and any other costs, this will translate directly to pre-tax profit. This study provides confidence that dairy farmers can rely on PLI to deliver bottom-line financial benefits.

It also provides data to demonstrate the statistical relationships between the component parts of PLI and of other potential composite genetic indexes, with technical and financial performance. This should ensure they can be developed in the knowledge of their relationship with performance data.

Extra information

Further to the study, Promar carried out an additional research project entitled 'An evaluation of factors affecting the utilisation of genetic information by GB dairy farmers'.

Table 1. Average costs of production, 2015–2020 (£/kg cold deadweight)

Performance of herds (grouped by PLI)			
	Top 25%	Average	Bottom 25%
PLI (average per record in group)	**166.4**	**87.9**	**-16.8**
PLI (average per herd in group)	**155.6**	**68.4**	**-20.2**
Herd size (cows)	303.6	254.4	196.1
Milk yield (litres)	10,683	9,782	8,554
Milk price (p/litre)	30.47	30.39	30.12
Milk income (£/cow/year)	£3,255	£2,972	£2,576
Concentrate usage (£/tonne)	4.181	3.628	2.833
Concentrate price (£/tonne)	£230.50	£232.30	£234.40
Feed rate (kg/litre)	0.391	0.371	0.331
Total feed cost (£/cow/year)	£1,092	£958	£758
Margin over purchase feed (£/cow/year)	**£2,163**	**£2,014**	**£1,818**
Calf income (£/cow/year)	£173	£155	£146
Vet and medicine (£/cow/year)	£109	£98	£76
AI and semen (£/cow/year)	£54	£46	£39
Net replacement cost (£/cow/year)	£273	£270	£240
Direct forage costs (£/cow/year)	£82	£85	£81
Genetically Influenced Margin (£ per cow)	**£1,818**	**£1,670**	**£1,529**

QuarterPRO

Background

Mastitis is one of the most common health problems on dairy farms. Its treatment and control are one of the highest costs to the British dairy industry. It is a very painful condition and results in lower production, increased costs and a poorer-quality product. There is a greater need to use antibiotic treatments if mastitis control is poor.

QuarterPRO is an industry initiative to promote and improve udder health.

QuarterPRO is a four-step process

1. PREDICT	2. REACT
Analyse data	Decide what to do
3. OPTIMISE	**4. REVIEW**
Take action on farm	Check results

Figure 4. Flowchart of Mastitis Control Plan process

1. Sit down with the farm team and advisers once a quarter – review clinical mastitis and somatic cell count data. Use the Mastitis Pattern Analysis Tool to **PREDICT** the most important udder health issues on farm in the next quarter.
2. Identify key management areas to be addressed and **REACT** by deciding on management changes – use AHDB pattern-specific resources.
3. Work together as a team to **OPTIMISE** udder health.
4. **REVIEW** on a quarterly basis to monitor progress and changes in udder health patterns.

The following resources are available as part of the QuarterPRO initiative at **ahdb.org.uk/quarterpro**:

- Managing mastitis
- The QuarterPRO approach factsheet
- Control of contagious mastitis
- Control of heifer mastitis
- Dry cow management
- Control of environmental mastitis in lactation

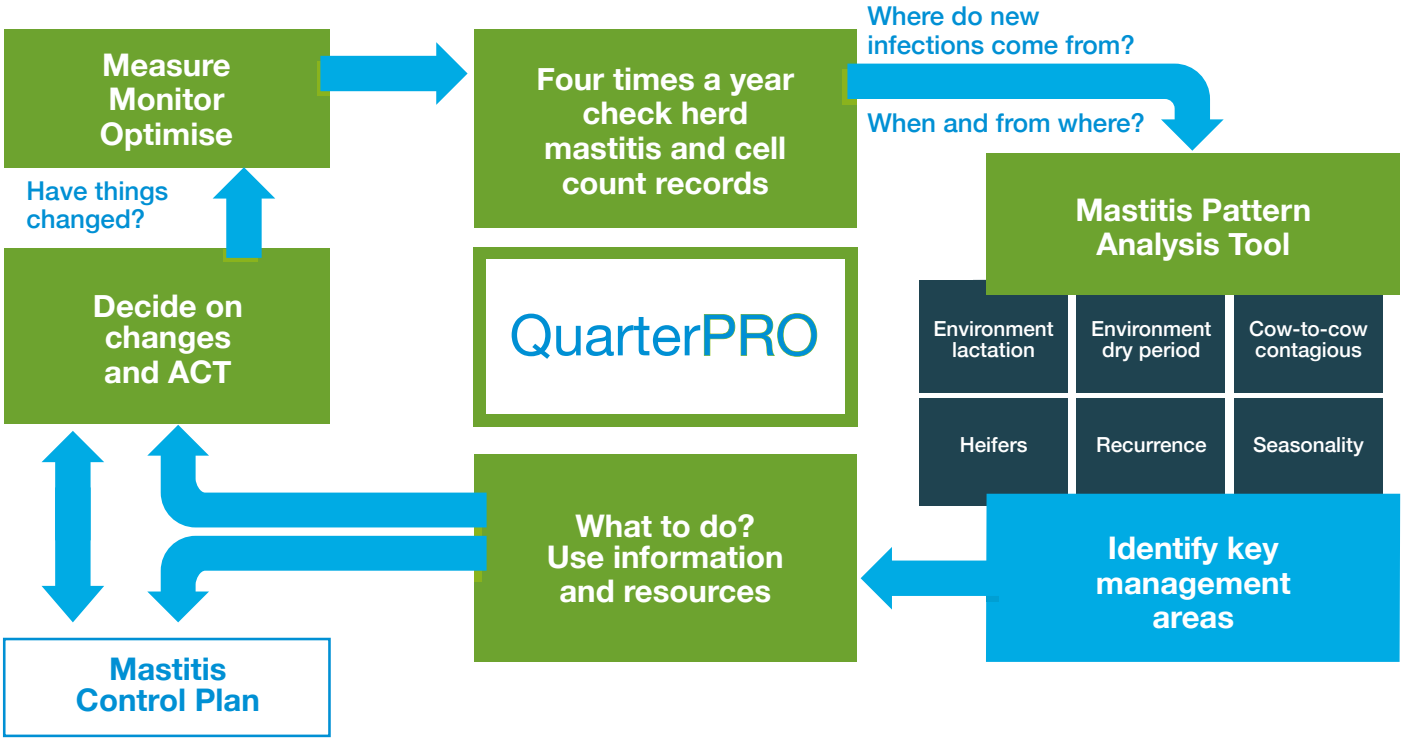


Figure 5. Flow chart of QuarterPRO process

Mastitis Pattern Analysis Tool: A tool to help farmers make better decisions about mastitis management in their herds

MASTITISCONTROL

Background

The introduction of the AHDB Mastitis Control Plan has provided a structured framework for a holistic, evidence-based approach to mastitis control. In 2018, an AHDB Dairy-funded project created an electronic Mastitis Pattern Analysis Tool that provides a fully automated method of making an initial herd-specific assessment based on herd somatic cell count and clinical mastitis records.

How does it work?

This tool provides a fully automated method of assessing the predominant mastitis infection patterns present on farm, using somatic cell count (SCC) and clinical mastitis records. Milk-recording herds are at an advantage as cow SCC information is readily available.

Using the tool, records are converted and merged into a simple output, allowing farmers to assess the patterns of mastitis in the herd.

Key benefits

- An effective way to track udder health
- Identifies problem areas and potential risks to udder health
- Identifies the predominant mastitis infection pattern present in the herd
- Helps dairy farmers prioritise key management areas

Extra information

The Mastitis Pattern Analysis Tool is available for download at **ahdb.org.uk/mastitis-pattern-analysis-tool**

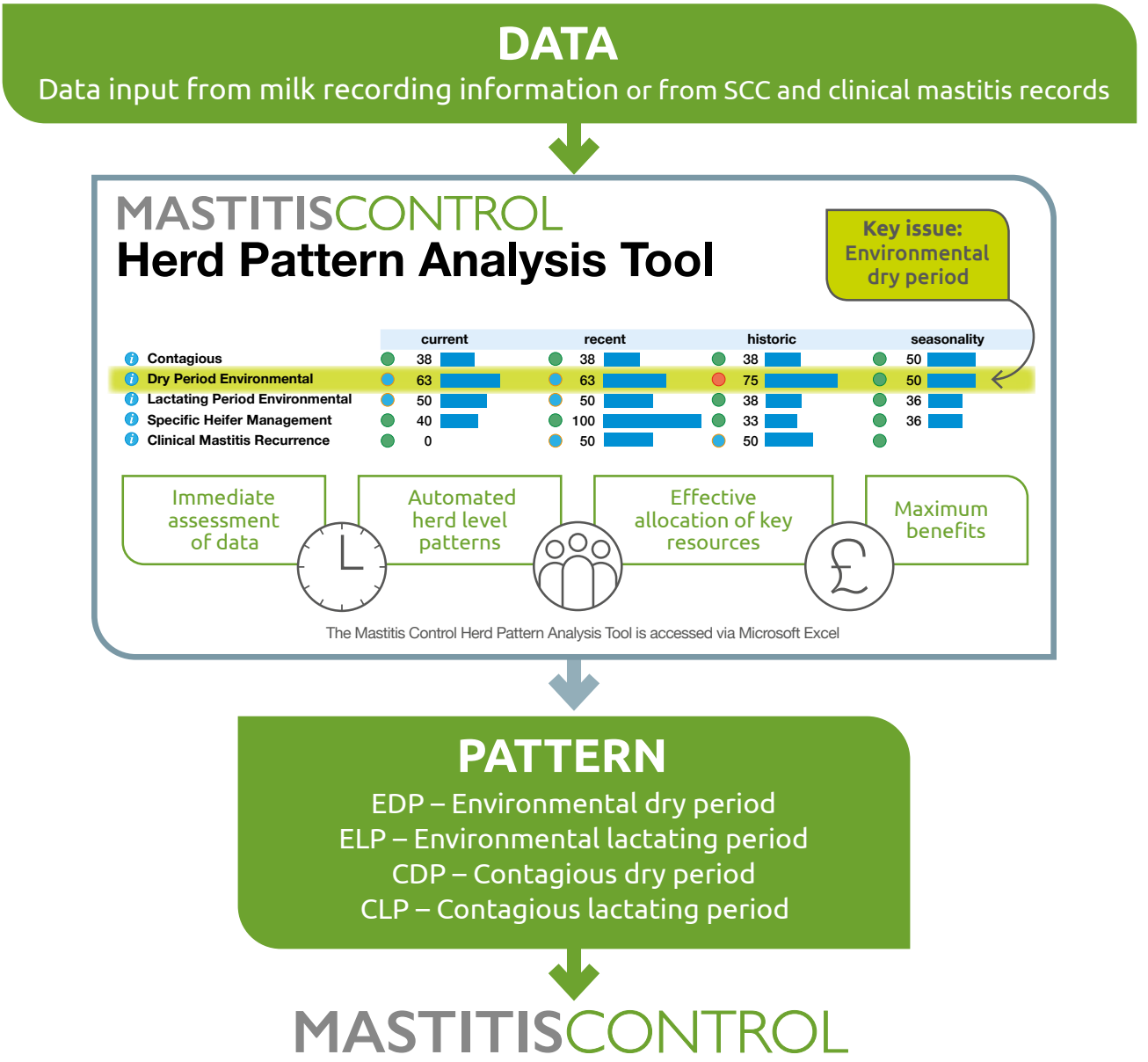


Figure 6. Flowchart of Mastitis Control Plan process

Healthy Feet Lite

Background

The AHDB lameness app is being developed through the dairy improvement programme, which is funded by Welsh Government. The prime focus is to develop a mobile application that is a practical collection and reporting tool for users to identify lame cows, recurring lame cows, lameness type and incidence levels.

Aims

The app will be aimed at multiple different user types, including mobility mentors, farmers, registered mobility scorers (RoMS) and cattle hoof trimmers.

What we did

The app is a tool to support the Healthy Feet Programme, which is delivered by trained mobility mentors. It adopts a structured, evidence-based approach to assess the risk factors on individual farms and produces a farm-specific plan to tackle disease and production management issues which are then monitored on an ongoing basis. These steps will be supported by the functionality of the app with access to the documents required to complete an assessment.

The app's functionality includes the ability to create herd dashboards with multiple different levels depending on the user type, to mobility score with and without ID, to input treatments for lame cows and to be able to look up previous treatments, to show summarising reports of individual and group data and to link to relevant AHDB resources such as the lesion card and cost calculator.

The contract for the work began late in 2020, and the project is currently still in development; completion and delivery of the app should take place in late autumn 2021.

Extra information

More information about the Healthy Feet Programme and Healthy Feet Lite can be found on the AHDB website at **ahdb.org.uk/healthy-feet and ahdb.org.uk/knowledge-library/healthy-feet-lite**

Reducing the risk of transmission of digital dermatitis in the dairy herd

Amy Gillespie[1], Stuart Carter[1], Roger Blowey[2], Nicholas Evans[1]

1. Department of Infection Biology and Microbiomes, Institute of Infection, Veterinary & Ecological Sciences, University of Liverpool
2. Appithorne, Minsterworth, Gloucester

Key messages

- Pathogenic *Treponema* are highly associated bovine digital dermatitis (BDD) in dairy cows
- Contaminated foot-trimming equipment may be involved in spread of treponemes between cows
- To reduce the risk of spread of digital dermatitis, disinfection of the foot-trimming blades should be considered
- A 20 second contact time with 1% FAM®30, 2% Virkon® or 2% sodium hypochlorite has been shown to be effective
- A disinfection protocol, for use during foot trimming, is available at: **ahdb.org.uk/reducing-spread-of-DD**

Background

Bovine digital dermatitis (BDD) is an infectious foot disease of cattle, affecting a large proportion of dairy herds. Active lesions cause extreme pain and are associated with significant lameness, making BDD an important economic and welfare concern.

Current prevention and treatment approaches fail to fully control digital dermatitis spread, with the disease frequently recurring.

Pathogenic spirochaetes belonging to the genus *Treponema* have been isolated from and are highly associated with BDD lesions. How BDD spreads is yet to be fully defined, although there is epidemiological evidence of spread via unsterilised foot-trimming equipment, and in particular, trimming blades.

Previous research has shown that hoof knives used to routinely trim cows' feet become contaminated with these infectious treponemes. Contamination of blades during trimming may spread BDD if the micro-organisms survive long enough to be transferred to another foot.

Aims of the study

This research aims to:

- Develop on-farm protocols to eliminate DD treponeme infection reservoirs
- Communicate these to those working with cows' feet and determine whether that advice is being used

We set out to measure the impact of our research (and associated knowledge transfer) on improving both understanding and practice of all professionals who trim cows' feet to prevent the transmission of BDD between cattle during foot trimming.

What we did

We investigated the disinfection efficacy of popular disinfectants against BDD-associated treponemes on

Figure 7. Protocol to eliminate viable bacteria from foot-trimming knives and user gloves, thereby minimising the spread of digital dermatitis. Full details can be found on the' Reducing the spread of digital dermatitis by disinfection of hoof-trimming equipment' web page, ahdb.org.uk/knowledge-library/cattle-foot-trimming-equipment-disinfection

foot-trimming blades and showed that 20-second contact with 1% FAM®30, 2% Virkon® or 2% sodium hypochlorite effectively eliminated the potential for transmission.

A standardised blade disinfection protocol was developed based on this data which we recommend as part of a holistic approach to BDD infection control. The disinfection protocol, to be applied during foot trimming, is available online at **ahdb.org.uk/reducing-spread-of-DD**

Having developed the disinfection protocol, we communicated it to dairy farmers, vets, and commercial cattle foot-trimmers and measured uptake.

There were three stages in this study:

- An initial questionnaire and knowledge exchange
- Dissemination of questionnaire results and further knowledge exchange
- A follow-up questionnaire

Results

The initial questionnaire indicated that more than half of participating farmers, commercial foot-trimmers and vets were not considering hand or hoof-knife hygiene within working practices. A year later, after the

circulation of a foot-trimming hygiene protocol and a comprehensive knowledge exchange programme, a second survey showed 35/80 (43.8%) farmers, commercial foot-trimmers and vets sampled considered they now were more conscious of the risk of spreading BDD while foot trimming. Moreover, 36/80 (45%) had enhanced hygiene practices, benefiting an estimated 5,130 cows trimmed each week across 1,383 farms.

Participants who had seen both the foot-trimming hygiene protocol developed with AHDB Dairy and other articles about foot-trimming hygiene were more likely to have changed working practices. Barriers to improving biosecurity practices included accessing water and cleaning facilities on farms.

Outcomes

Disinfection can reduce the risk of spreading the treponemes associated with digital dermatitis between dairy cows on hoof knives. Communication of a recommended disinfection protocol by AHDB Dairy and the University of Liverpool has raised awareness and increased the proportion of those working with cows' feet who have improved their hygiene practices.

Extra information

For more information, please visit the AHDB website: **ahdb.org.uk/reducing-spread-of-DD**

The full research reports were published open access as below:

- Gillespie, A., Carter, S., Blowey, R., Staton, G., Walsh, T., & Evans, N. (2021). *Measuring the impact of bovine digital dermatitis research on knowledge and practice of biosecurity during cattle foot-trimming*. Journal of Dairy Research, 1-4. doi. org/10.1017/S0022029921000170
- Staton, G., Gillespie, A., Evans, N., Blowey, R., & Carter, S. (2020). *Controlling the spread of bovine digital dermatitis*. Journal of Dairy Research, 87(1), 140-140. doi.org/10.1017/S0022029920000072
- Gillespie, A. V., Carter, S. D., Blowey, R. W., Staton, G. J., Evans, N. J. *Removal of bovine digital dermatitis-associated treponemes from hoof knives after foot-trimming: a disinfection field study*. BMC Vet Res 2020; 16:330. doi: 10.1186/s12917-020-02552-8
- Gillespie, A., Carter, S. D., Blowey, R. W. & Evans, N. (2019). *Survival of bovine digital dermatitis treponemes on hoof knife blades and the effects of various disinfectants*. Veterinary Record doi: 10.1136/vr.105406

Is preventative trimming of in-calf heifers worthwhile?

Sara Pedersen, Dr. Nick Bell, Dr. Chris Hudson and Prof. Martin Green, University of Nottingham;

Key messages

- Preventive hoof trimming is a widespread practice, with just over 80% of GB dairy farmers incorporating it in their lameness management program
- More than half of farms are using a professional hoof trimmer
- Although the five-step method is the perceived gold standard method, there is a large variation in how this is applied by experts and a lack of consensus on how to approach step 1, which is the measurement and assessment of toe length
- The commonly used method of measuring toe length (measuring from where the horn is palpably hard at the coronary band to a point at the toe) appears to be most predictive of sole depth under the tip of the pedal bone. However, there is considerable variation between observers when making this assessment

Prof. Jon Huxley, Massey University

Background

Lameness is the most significant welfare concern in dairy cattle and a substantial challenge to the profitability, sustainability and reputation of the industry. Preventive hoof trimming can be defined as 'trimming which takes place as a preventive measure to correct overgrowth of the hoof in the non-lame cow and reduce future risk of lameness'. While it is considered an important component of lameness prevention, evidence supporting trimming technique and optimal frequency of trimming are limited for the modern dairy cow. Therefore, current protocols are largely based on the limited research available and the opinion of industry professionals, including vets, hoof trimmers and consultants.

Study aims

The aim of this study was to add to the evidence base in this area by conducting a randomised control trial (RCT) on a specific aspect of the hoof trimming technique. The individual objectives were to conduct a stakeholder consultation, convene an international working group and develop best practice protocols for implementation on farm.

What we did

The project comprises six studies:

- Electronic and paper questionnaire survey on foot-trimming practices and future research priorities circulated to GB dairy producers
- International expert consultation on foot-trimming method, research priorities and RCT design
- Reliability of using ultrasound to assess sole thickness in fresh cadaver hooves
- Determination of the relationship between anatomical dimensions and sole thickness measured in fresh cadaver hooves
- Repeatability of different assessments of toe length assessment in cadaver limbs and live cows
- Forthcoming: RCT to compare the effectiveness of hoof trimming eight weeks prior to first calving in dairy heifers with a negative control (no trimming)

Results

The farmer survey results highlighted that preventive hoof trimming is a widespread practice on GB dairy farms, with 82.4% implementing it as part of their lameness control. Higher yielding herds were significantly more likely to undertake preventive hoof trimming. Both external hoof trimmers and farm staff were undertaking trimming. The most common questions farmers have regarding preventive hoof trimming are when they should it implement within the lactation cycle and which technique they should use.

The expert consultation showed a large variation in the approach taken to measuring toe length and the appropriate length to use. As a result, there was a strong steer towards the standardisation of toe length being a research priority.

A cadaver study was undertaken to formulate a set of criteria for determining optimal toe length, but was not able to determine a superior method of measurement that could then be assessed in a field trial. A pilot study raised concerns over the repeatability of this measurement and the difficulty with incorporating this into future analysis of predictiveness.

Outcomes

The study confirmed that preventive hoof trimming is a widespread practice, and therefore improving outcomes has the potential to have a large impact on lameness prevalence within the industry. It also confirmed that there has been a significant shift away from hoof trimming being done by vets in the last 20 years, with this trimming being done almost entirely away from vet supervision.

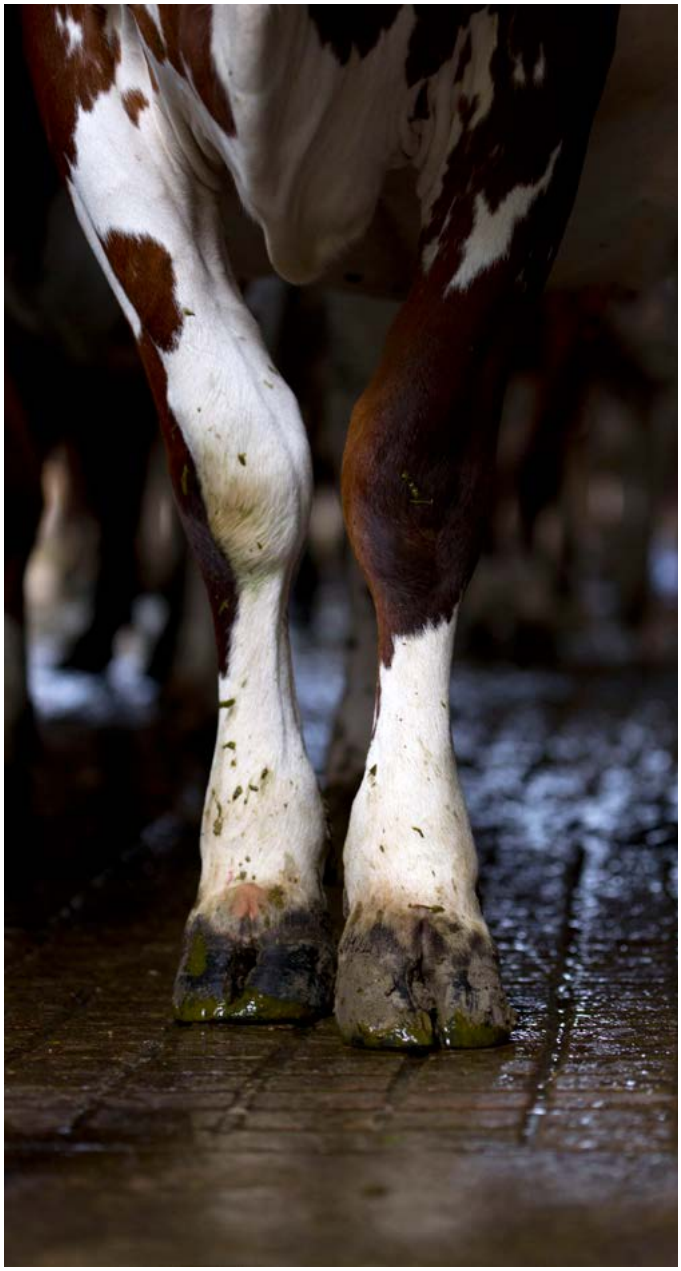
While the farmer survey highlighted key questions regarding preventive hoof trimming, it also indicated that questions still exist about areas of lameness where we already have evidence-based approaches and protocols. This shows that we need wider-spread and targeted knowledge exchange for maximum impact from new research findings.

The need to ensure consistency when assessing toe lengths was shown, which has implications for training and ensuring consistency and confidence, since inaccurate measurements can inadvertently lead to thin soles.

Further research is needed to better inform on-farm practice, specifically around trimming technique and whether we should be trimming in-calf heifers, and to find out if more consistent measurements for assessing toe lengths can be determined. The planned trial work will address some of these and provide evidence-based protocols for implementation on farm.

Extra information

Submitted to journal Vet Record: *Preventive Hoof Trimming in Dairy Cattle: Determining current practices and identifying future research areas.*



Setting our heifers up to succeed – effect of anti-inflammatories for treatment and prevention of lameness

Dr. James Wilson, Duchy College; Prof. Martin Green, Laura Randall, Dr. Catrin Rutland, Dr. Nick Bell, Heather Hemingway-Arnold, Julia Thompson, Nikki Bollard, University of Nottingham; Prof. Jon Huxley, Massey University

Key messages

- The routine administration of NSAIDs at first and subsequent calving, and at every lameness event is critical in reducing an animal's risk of becoming lame in the future
- We believe NSAID use minimizes the effect calving has on the functional anatomy of the foot, meaning that the foot can function better
- We also believe appropriate pain management may minimize the risk of "pain wind-up" or hyperalgesia
- The effect of using NSAID was substantial, with an absolute reduction in lameness prevalence of 10% and in severe lameness of 3%. The risk of animals getting this treatment being culled was also significantly reduced

Background

Lameness presents one of the most pressing challenges facing the global dairy industry. Claw horn lesions (CHL) are reported as the most common cause of lameness in intensive dairy systems. Despite their prevalence, our understanding of pathogenesis and long-term treatment outcomes are poor at best. A number of recent advances have pointed to the potential role of inflammation in the development of CHLs, either subacute systemic inflammation associated with parturition or localised inflammation in the hoof derived from active CHLs. It has been demonstrated that lameness begets future lameness. Managing the inflammation associated with parturition and CHL onset may, in turn, provide an effective strategy for managing lameness on farm.

Aims of the study

The current study was designed to investigate the effects of routine long-term treatment with the non-steroidal anti-inflammatory drug ketoprofen at calving and during treatment for lameness on the future risk of lameness and culling.

What we did

A cohort of dairy heifers was recruited from one commercial, intensively managed dairy herd for 34 months and randomly allocated to one of four treatment groups prior to first calving (Table 2).

Table 2. The different treatment regimens used in the study

Treatment	Lameness trim*	Lameness NSAID
Group 1	✓	✗
Group 2	✓	✓
Group 3	✓	✓
Group 4	✗	✓

*Unless severely lame

The lactating herd was mobility scored fortnightly to identify lame animals for treatment as soon as they became lame.

Animals were tracked for the duration of the trial. Animals were also mobility scored fortnightly by independent scorers who were not involved in the study and did not know which cows had been treated. Statistical analyses were used to evaluate the impact of treatment on the on-going risk of lameness and of time to culling.

Results

Cows that received NSAID at first and subsequent calvings, and at lameness events, were at a significantly reduced risk (by approximately 30%) of being scored as lame or culled when compared to those that received no NSAID at calving or when being treated for lameness.

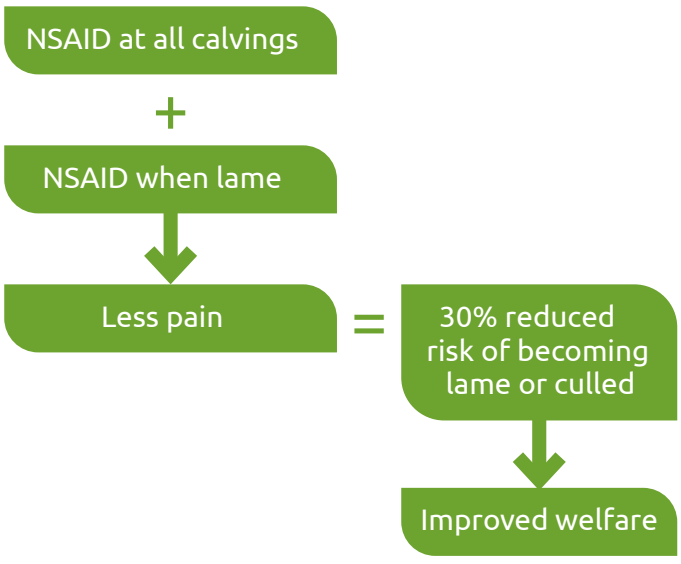


Figure 8. The lifetime risk of lameness and culling is reduced when cows are treated with NSAIDs at all calvings and lameness events

The lameness effect size identified was large and indicated that using NSAIDs in a group of cows at every calving and every time they were treated for lameness, would lead to an absolute reduction in

lameness prevalence of approximately 10% and in severe lameness prevalence of 3%, compared to animals not treated with NSAIDs.

Outcomes

We found that treatment with ketoprofen at the first and every calving and at every lameness event, reduced the lifetime risk of lameness (any or severe) and culling during the 34-month randomised controlled trial.

We believe systemic and local inflammation at the time of calving, and at lameness events, predisposes cows to future lameness. This is limited by routine treatment with NSAIDs.

In addition, the repeated administration of NSAIDs at painful events (e.g. calving and lameness) may result in an interruption in pain signaling pathways leading to a substantial improvement to animal welfare through a reduction in pain up-cycling.

The administration of NSAIDs at calving and when treated for lameness appears to help reduce the risk of further cases of lameness, and consequently less pain, in future life as well as reducing the risk of culling.

Digital cushion and historic lameness events

Dr. James Wilson, Laura Randall, Prof. Martin Green, Dr. Catrin Rutland, University of Nottingham; Chris Bradley, Sir Peter Mansfield Imagine Centre, University of Nottingham; Holly Ferguson and Ainsley Bagnall, Scotland's Rural College; Prof. Jon Huxley, Massey University

Key messages

- Animals with a history of lameness and low BCS were more likely to have less digital cushion within their claws at the time of slaughter
- This could be related to genetic and developmental factors in early life
- These factors could then lead to an animal suffering from claw horn lesions, leading to the metabolism of the digital cushion as part of the inflammatory process
- The presence of claw horn lesions is likely to predispose an animal to future claw horn lesions through the depletion of digital cushion adipose tissue

Background

Claw horn lesions (CHL e.g. sole haemorrhage, sole ulceration, and white line disease) are associated with changes of the functional anatomy of the hoof in dairy cows and are highly prevalent in the global dairy herd. The digital cushion is understood to be a vital structure in the prevention of CHL. CHLs have previously been shown to lead to pathological change to the pedal bone; however, their effects on the digital cushion are not known.

Aims of the study

The current study was designed to investigate associations between animal level variables (including lameness history) and the volume of, and fat content within, the digital cushion in adult dairy cattle at cull. The secondary objective of the study was to quantify the volume and fat fraction of the digital cushion in a sample of culled dairy cows.

What we did

102 pairs of hindfeet, collected from adult Holstein dairy cows culled from a research herd, were scanned in a research grade MRI scanner. Volume and fat measurements were calculated for each digital cushion within each claw using a single scanning sequence. Mobility scores and body condition scores (BCS) were collected at least fortnightly during the lactating lifetime of the cows. The combined volume of digital cushion in the lateral claws was used as the outcome variable in multivariable linear models.

Results

The more-lame an animal was (either from CHL records, or mobility scoring) throughout its lactating life, the less digital cushion it had in its lateral claws at slaughter. Cows with a BCS over 3, cows culled later in lactation, and heavier cows were more likely to have a higher volume of digital cushion in the lateral claws.

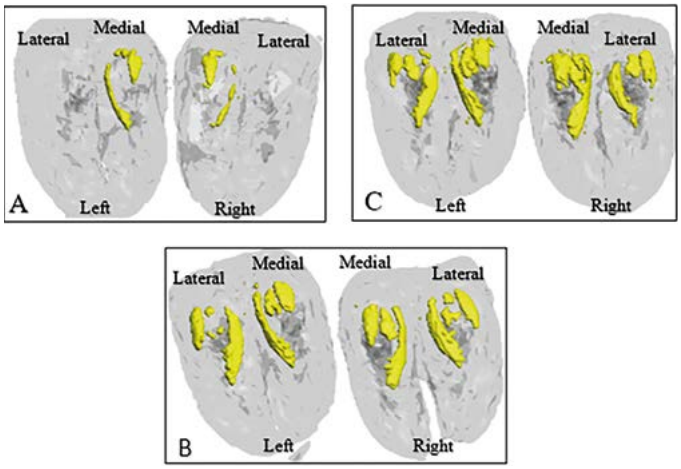


Figure 9. The reconstructions view the hoof-capsule from the plantar aspect, with the yellow regions showing digital cushion and the grey areas representing other tissues within the foot

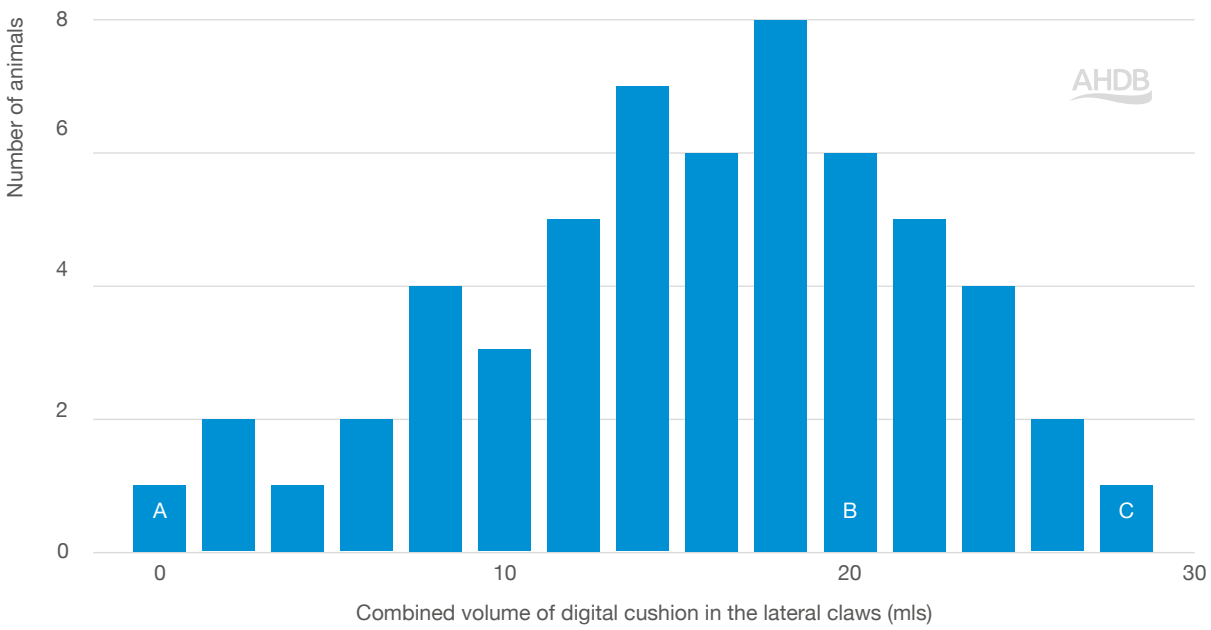


Figure 10. The combined volume of digital cushions in 104 lateral claws

Outcomes

The results of this study are believed to be related to the effects of a range of factors broadly associated with genetic, developmental, and disease-related inputs. Our understanding of how we can select for genetically more robust animals and how we can precondition the hoof before first calving needs to be improved to reduce the risk of future CHL in adult dairy cattle.

More information on the best treatment regimens and their effect on hoof anatomy would also help reduce the recurrence of CHL in the current lactation and future lactations.

Extra information

This study was published in the Journal of Dairy Science in June 2021.

Understanding the genomic resistance to claw horn disruption lesions in dairy cattle

Bethany Griffiths, Alkiviadis Anagnostopoulos, Matthew Barden, Prof. Georgios Oikonomou, University of Liverpool; Dr. Androniki Psifidi, Royal Veterinary College; Prof. Georgios Banos, Scotland's Rural College

Key messages

- The sole soft tissues are at their thinnest around calving, highlighting the importance of fresh cow management
- First lactation animals have significantly thinner sole soft tissues (fat pads) than their older counterparts. First lactation animals that develop a sole ulcer have thinner fat pads immediately after calving
- Management of first lactation animals, especially during the period around calving, may be particularly important
- This analysis is a first look at the sole soft tissue thickness measurements. The full analysis currently in progress includes key factors related to metabolic stress, the influence of the immune system, hormonal profiles, thermography and foot anatomy

Background

The effects of lameness are wide-ranging: reducing cow welfare, milk yield, fertility and significantly increasing costs on farm. Given the substantial numbers of affected cows, it is not surprising that lameness was listed as the top welfare challenge facing the cattle industry. Over 90% of lameness cases are in the foot, with a large proportion caused by non-infectious claw horn disruption lesions (CHDLs). The term CHDL includes sole ulcers, sole haemorrhage and white line disease. Despite their importance, how these lesions develop is not yet fully understood.

Aims of the study

This project aims to evaluate key factors that underlie or predispose to the development of claw horn disruption lesions in dairy cows by examining foot anatomy and structure, fat mobilisation, metabolic stress and the influence of immune and hormonal profiles around calving and in the early lactation period using repeated measurements on a large number of Holstein cows and advanced statistical analysis.

What we did

2,353 Holstein dairy cows were enrolled approximately 30–60 days before calving. They were then re-examined shortly after calving (within seven days), during early lactation (50–100 DIM) and in late lactation (170–200 DIM).

At each examination all cows were mobility scored, body condition scored and height taken. The animals were restrained in a crush, and all four feet were checked for any lesions. An ultrasound image was taken of the digital cushion in the back-left foot, and thermography images (heat maps) were taken of both hind feet. These animals were then blood sampled and these samples stored for later analysis.

14,899 thermography and 7,866 digital cushion images have been collected and analysed. A further 7,015 serum samples are stored in preparation for analysis of the metabolic, inflammatory and hormonal status of the animal.

Results

The soft sole tissue thickness (SSTT) was at its thinnest in freshly calved cows, having decreased from calving, before then increasing throughout lactation. Heifers had significantly thinner SSTT compared to higher lactation animals, while animals with three or more lactations had significantly thicker SSTT compared to second lactation animals.

There were significant differences in SSTT between farms. This confirms previous studies that have shown that genetics, heifer management, and farm characteristics can all affect the development of the digital cushion.

This initial analysis has also indicated that taller cows had thicker SSTTs, while cows with thinner soles had thicker sole soft tissues.

SSTT is impacted by:

- Stage of lactation
- Age of cow
- Lactation number
- Cow height
- Genetics
- Heifer management
- Farm characteristics

Outcomes

Initial results have highlighted that fresh animals and heifers have significantly thinner soft tissues in the sole, and our project adds further evidence that fresh cow management and heifer management are important stages for managing the risk of lameness in the production cycle of dairy cows.

These results are from a first look at the SSTT data from this project. The full analysis will include the results from the laboratory work, the foot anatomy measurements and the thermography data.

The importance of dam infection on the risk of Johne's disease

Dr. Stuart Patterson, Karen Bond, Dr. Steven van Winden, Prof. Javier Guitian, Royal Veterinary College; Karen Bond, National Milk Records; Prof. Martin Green, University of Nottingham

Key messages

- Cows may be transmitting MAP to their offspring at an earlier stage than had previously been thought
- MAP-positive cows are 2.6 times more likely to have MAP-positive offspring than MAP-negative dams
- Offspring are also more likely to test JD-positive if their dam herself seroconverts later in life (i.e. even if the dam was test-negative at the time of calving)
- The management on farm of the offspring of MAP-positive animals has the potential to significantly reduce the time required to eliminate JD
- When a cow tests positive for JD, check if any of her calves are still in the herd and decide whether to manage them differently at calving and whether to breed replacements from them

Background

Johne's disease (JD) is caused by *Mycobacterium avium* subsp. *paratuberculosis* (MAP). In GB, 59–77% of dairy herds are believed to be MAP-infected. Most MAP-infection is believed to be picked up in the first few days of life, mainly through ingestion of bacteria through drinking contaminated milk or the oro-faecal route. Vertical transmission may also play a role.

Clinical signs of JD are often not seen until 3–4 years of age. Clinically affected animals continue to deteriorate and are usually culled on welfare grounds. Financial losses are associated with increased culling costs/mortality and subclinical costs, including weight loss, reduced milk yield and poor fertility. There is no treatment for JD.

It is well accepted that calves of cows that are JD test-positive at calving are at higher risk of picking up the infection. JD-test positive dams are more likely to be excreting high quantities of MAP in colostrum and faeces, which may contaminate the calf during calving or suckling.

Herd-level control is based on the prevention of transmission and removal of infectious individuals.

Aims of the study

An important question is whether there are risk cows in the early stage of disease, but testing JD-negative, who will spread it to their calves. The aim of this study was to investigate the importance of dam MAP-infection status on a calf's likelihood of testing positive for MAP during its lifetime, considering not only the status of the dam at the time of calving but also whether it was identified as 'MAP-infected' at any point after that calf was born. This long-term study offers a rare and valuable insight into how disease spreads within herds.

What we did

A cohort of 440 newly born calves in six UK herds was recruited in 2012–2013. Cows in the milking herd were routinely monitored for the presence of MAP using quarterly milk enzyme-linked immunosorbent assay (ELISA) testing for up to six years while they remained in the milking herd. Statistical analysis compared the risk of JD infection in calves born before and after their dams were identified as being seropositive for JD. The magnitude of the effect of dam status was then compared with that of other risk factors to understand its relative importance.

Results

Dam status was the only factor significantly associated with time to an individual testing MAP-positive. When compared to negative dams, calves born to a dam that was positive at the time were 2.6 times more likely to test positive for JD during their lifetime.

Where cows tested positive within 12 months after calving, the risk of these calves' testing positive for JD during their lifetime was 3.6 times higher than for the calves of cows that still tested negative. Even when the dam tested positive for the first time, more than 12 months after calving, her calves' risk of testing positive was 2.8 times higher.

This important research shows the need not just to consider JD status of cows at calving but to continue to monitor her status later in life. The economic implications of taking action to reduce the risk of MAP infection are, therefore, well worth considering.

Outcomes

These findings suggest that cows may be transmitting JD to their calves at an earlier stage than had previously been thought. It raises important questions about how this transmission may be occurring.

It is unclear exactly what the reasons are for this increase in risk. It may be because of a drop in immunity immediately before calving, allowing transmission in the last stages of pregnancy. Alternatively, it could be due to a brief period of shedding at calving, which might not be enough for these cows to test positive for JD.

Prior to seroconversion, levels of MAP shedding are assumed to be low, and industry guidance in the UK does not make recommendations for the management of calves that are born before a cow first tests positive. This study provides strong evidence that calves are at higher risk of JD even when their dams are negative at the time of calving and seroconvert more than 12 months after the calf's birth.

Cow with Johne's Disease at calving:

calf 2.6x

more likely to test +ve for JD in their lifetime

Cow that develops Johne's Disease after calving:

calf up to 3.6x

more likely to test +ve for JD in their lifetime

Figure 11. Calves whose dam tests positive, even after calving, are more likely to test positive for JD than calves whose dam stays JD negative

These findings may explain part of the current difficulties in eliminating JD from infected herds. The economic implications of taking action are, therefore, well worth considering.

Johne's diseases: TB impact

Erica Nunney, Dr. Matteo Crotta, Karen Bond, Dr. Steven van Winden, Prof. Javier Guitian, Royal Veterinary College; Karen Bond, National Milk Records; Prof. Martin Green, University of Nottingham

Key messages

- There are small differences in the JD milk ELISA results of 'infected' and 'non-infected' cows following bTB skin testing
- 'MAP-infected' cows are more likely to test positive immediately after bTB testing but non-infected cows are no more likely to falsely test as positive if tested at the same time
- The accuracy of JD milk ELISA testing may be better immediately after bTB skin testing (1-5 days)
- JD testing strategically based on timing after bTB testing could play a powerful role in earlier detection of MAP-infected cows

Background

Johne's disease (JD) is caused by *Mycobacterium avium* subsp. *paratuberculosis* (MAP). Bovine tuberculosis is caused by *Mycobacterium bovis*. The single intradermal cervical comparative test (SICCT) is used to determine bTB status in the eradication scheme in the UK. The bTB skin test has been widely reported to interfere with the milk ELISA results for JD. Understanding the relationship between bTB and JD is required for the improvement of management and control of Johne's disease.

In GB 59–77% of dairy herds are believed to be MAP-infected. Johne's disease control in the UK relies on repeated testing with selective culling and targeted management due to the long varying incubation period and limited accuracy in the diagnostic test.

Aims of the study

The aim of this study was to look at the relationship between the Bovine TB SICCT skin test and Johne's disease milk ELISA performance. Our objectives in this study were to:

- Estimate the length of time SICCT impacts on milk ELISA test results
- Assess whether such effect differs between 'MAP-infected' and non-'MAP-infected' cows
- Estimate the impact of the time between SICCT and JD testing on the performance of JD ELISA results in classifying cows according to their JD infection status

What we did

The study used data provided by the National Milk Records group (NMR) containing results of 3,977,621 JD milk ELISA tests carried out between 01/01/2012 and 28/09/2018. bTB test dates were provided by the UK's Animal Plant Health Agency (APHA). Each JD ELISA test was matched to the closest preceding bTB test.

Any cow with two positive JD test results within four consecutive tests is classified as 'MAP-infected'. Statistical analysis looked at the association between JD milk ELISA test results and time interval between bTB testing and testing for JD. JD milk ELISA test results from 466,374 cows were analysed. The impact bTB testing had on JD milk ELISA test performance was evaluated.

Results

ELISA values of cows classified as 'infected' were highest when JD testing was closer in time to bTB testing, suggesting the bTB skin test enhances the antibody response for MAP in 'MAP-infected' cows.

For cows assumed to be 'non-infected', JD ELISA values were highest 11-20 days after bTB testing.

Diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were found to be highest when JD testing took place 1–5 days after bTB testing.

The results provide strong evidence that the effect of bTB on serological response against MAP is different for 'MAP infected' vs. 'non-infected' cows and that interpretation of JD test results can be improved by considering time between bTB and JD testing.

Outcomes

bTB skin testing (SICCT) affects the serological response of cows against MAP in different ways depending on whether the cow is 'MAP-infected' or not. The probability of 'MAP-infected' cows testing positive increases immediately after bTB testing while the probability of non-infected cows falsely testing as positive during the same time window is not increased.

To increase the accuracy of JD milk ELISA testing, testing for JD 1 to 5 days after bTB testing could be of potential benefit. The risk of false negative and false positive results of the milk ELISA may be marginally higher when JD testing 6–60 days post bTB skin testing.

Extra information

Results of the first analysis of the cohort data (cows at third lactation) are published:

S. Patterson, K. Bond, M. Green, S. van Winden, J. Guitian. (2020). *Mycobacterium avium paratuberculosis infection of calves – the impact of dam infection status*, Prev. Vet. Med., 181 (2020), ISSN 104634

Johne's classification algorithm

Dr. Erica Nunneya, Dr. Matteo Crotta, Karen Bond, Dr. Steven van Winden, Prof. Javier Guitian, Royal Veterinary College; Karen Bond, National Milk Records; Prof. Martin Green, University of Nottingham

Key messages

- The algorithm for probabilistic interpretation of repeated JD tests allows for the inclusion of pre-testing information and the actual Optical Density (OD) values of the milk ELISA test
- The proposed probabilistic approach departs from the categorical classification of cows based only on JD test results as positive/negative and can integrate the biological effects of events such as the bTB test that might affect interpretability of the JD test result pattern
- The numerical probability provided by the algorithm can be presented together with the HerdWise classification system to enhance interpretation of repeated JD tests and provide better support for decision-making in regards to individual animals

Background

Johne's disease is caused by *Mycobacterium avium* subsp. *paratuberculosis* (MAP). Control of JD in the UK relies on repeated testing with selective culling and targeted management. However, due to the long, varying incubation period and limited accuracy of the diagnostic test, identifying JD infected cows poses a challenge for farm-level decision-making for individual cows. Currently, farmers are supported by a set of rules for the classification of animals based on repeated JD tests expressed as positive/negative.

A previous research partnership between the Royal Veterinary College and AHDB has shown how a probabilistic interpretation of repeated JD test results could provide better support on culling decisions at individual animal level.

In GB, 59–77% of dairy herds are believed to be MAP-infected. In the absence of a 'gold standard' for infected cows, probabilistic approaches allow maximising the use of farm-level and cow-specific information to better characterise the probability of JD infection of individual animals.

Aims of the study

The objective of the study was to support farm-level decision making with regard to individual animals by developing an algorithm for a probabilistic interpretation of repeated JD milk ELISA tests.

What we did

The classification algorithm was conceptualised within a Bayesian framework allowing calculation of a cow-specific probability of JD infection as a function of a set of farm-level and/or individual cow data.

Even before doing any test, the initial probability of the animal being infected is not assumed to be entirely unknown as this can be calculated from the herd prevalence or, if known, the infectious status of the dam.

After any JD milk ELISA test, information on the test result (OD value of the milk ELISA test), age of the animal at testing, and, if available, the time since the previous bTB skin test are used to update the probability of infection and provide the final probability of the animal being JD-positive.

Key results

When tested, the probability of JD infection calculated by the algorithm for cows classified as 'green' or 'red' remained well aligned with the classification rules (i.e. low probability for 'green' cows and high probability for 'red' cows). However, the numerical probability provided by the algorithm can support more informed decisions around the 'yellow' cows. In fact, cows that have been classified as 'yellow' by the current classification rules based on JD test pattern (with results expressed as positive/negative) can result in having a numerical probability that is comparable to that of the infected (or not infected) depending on the farm and cow-specific information fed into the algorithm.

Outcomes

Departing from the current classification rules based on the JD test results expressed as positive/negative and classifying the cows as 'green', 'yellow', or 'red', the algorithm represents a considerable improvement for decision making for individual cows. It allows for explicit inclusion of different streams of farm and subject-specific information that altogether accumulate to provide a numerical probability of JD infection.

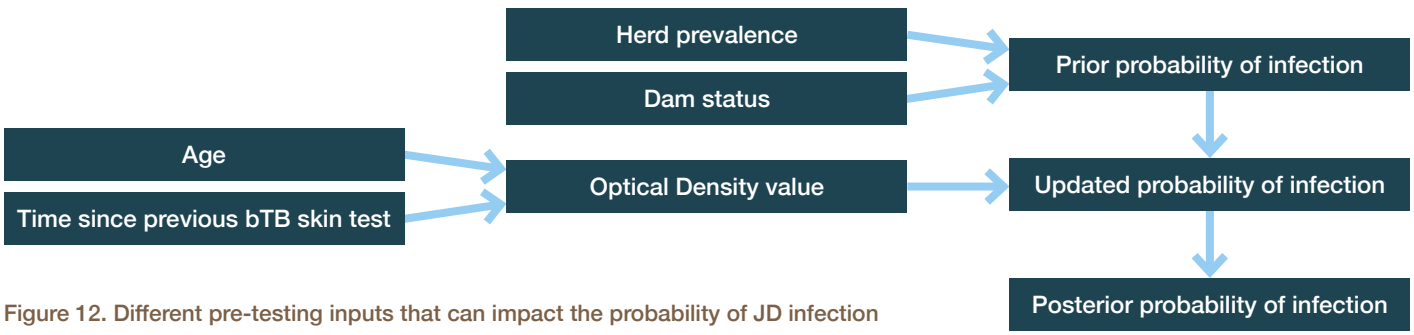


Figure 12. Different pre-testing inputs that can impact the probability of JD infection

An update on bovine ischaemic teat necrosis

Hayley Crosby-Durrani, Stuart Carter, Nicholas Evans, Uniersity of Liverpool; Joseph Angell, Wern Vets CYF

Key messages

- Bovine ischaemic teat necrosis is an emerging disease affecting the teats of dairy cows
- There are three clinical presentations
- Cows in their first lactation and in the first 90 days in milk are most at risk
- Potential farm-level risk factors include milking cows with chapped teats and/or udder cleft dermatitis (UCD)
- Cause is still to be determined, but improvements in overall teat and udder health may be important to reducing the disease

Background

Bovine ischaemic teat necrosis (ITN) is an emerging disease affecting the teats of dairy cattle. Many animals that develop ITN do not respond to treatment and are culled early. Little is known about the different presentations of the disease, how many farmers have experienced it, which cows are most likely to be affected or if there are any risk factors why one farm will have cases and other farms will not.

Currently, the cause of ITN is unknown. However, a pilot study had suggested a potential link with the same *Treponema* bacteria that are associated with digital dermatitis (DD). Anecdotally, cases appeared to be increasing across the whole of GB. Without clear research to build the foundations of the disease, treating and preventing ITN is challenging, with many more animals likely to be culled early.

Aims of the study

The aims of this investigation were the following:

- Describe the key presentations of the clinical disease to allow for quick identification, diagnosis and treatment
- Survey GB dairy farmers to find out how many had experience with ITN and identify if a potential group of animals are more likely to be affected than others
- Identify potential farm-level risk factors for further investigation
- Make progress in understanding the cause of ITN to provide evidence-based treatment

What we did

Images of the udders of 46 cows with 70 affected teats from 27 different farms were reviewed to develop a grading system.

Ten farms with suspect ITN cases were visited. Samples were collected, and the farmers were interviewed. A further 10 farmers were sent a pilot postal questionnaire.

A national postal questionnaire was sent to 1,855 farmers randomly selected from the AHDB database of dairy producers to understand the impact of ITN on the dairy industry and look for any potential farm-level risk factors. Farm-level risk factors were identified using a series of logistic regression models.

Farmers and vets that reported active cases of ITN when farm visits were not possible submitted samples to be included in the hunt for the cause. All samples were screened for DD treponeme bacteria using a PCR test.

Results

Three main clinical presentations have been described. Type 1 lesions are a well-demarcated, dry, red to black area, usually on the inside of the upper part of teat.

Figure 13. Photograph of a cow's teat with a typical type 1 presentation of ITN probability of JD infection

Figure 14. Photograph of a cow's teat with a typical type 2 presentation of ITN probability of JD infection

Type 3 lesions are when the teat has been damaged or removed due to the disease process.

Figure 15. Photograph of a type 3 ITN lesion in which the affected teat has been lost due to the disease

There were 228 completed questionnaires, which showed that ITN was widespread across GB, and 51% of farmers who responded had the first case of ITN on the farm in the period 1985–2018. Of these, 46.3% had the first case of ITN between 2015 and 2018.

First lactation cows in the first 90 days in milk were reportedly most at risk. Potential risk factors at farm level were found to be cases of udder cleft dermatitis and/or chapped teats in the milking herd.

No clear cause was detected, with more similarities between bacteria in the control teats than ITN teats (further work ongoing). Digital dermatitis treponemes no longer appear to be associated with PCR detection of DD treponemes in only 29.2% of ITN cases.

Outcomes

From this study, three key presentations have been identified to allow for rapid diagnosis and treatment of clinical cases.

The national postal survey confirmed that ITN is widespread across GB, with 51% of farmers having had the first (index) case of ITN in-between 1985 and 2018. This is rapidly increasing, with 46.3% of the index cases occurring in 2015–2018. The postal questionnaire and farmer interviews showed a similar finding: that first lactation cows in the first 90 days in milk are significantly more likely to be reported as having ITN. Knowing which animals are most at risk allows for careful monitoring in this period.

Udder cleft dermatitis and chapped teats in the milking herd were found to be potential farm-level risk factors. This is interesting and suggests that improvements in overall teat and udder health may be important to reducing the disease, and this potential link warrants further investigation.

While no clear cause has yet been identified, work is still ongoing in this area. The evidence for the involvement of DD treponemes has grown weaker, and further analysis should investigate any relationships with alternative pathogens. As the cause has not been identified, it is not possible to provide evidence-based treatment options at this time.

Practical housing and management changes for healthy and productive calves

Robert Hyde, Martin Green, Chris Hudson, Pete Down, University of Nottingham

Key messages

- Analysis of national data suggests calf mortality is associated with breed type, sex, the month of birth and environmental temperature
- Several factors were associated with health and production outcomes in calves on dairy farms, including stocking demographics, milk/colostrum feeding practices, and both environmental hygiene and temperature
- These factors were tested in a randomised controlled trial by implementing an evidence-based calf health plan. Interventions from the plan were demonstrated to improve growth, mortality and diarrhoea rates
- As these studies suggested that environmental temperatures appear to be associated both with mortality and growth rates, 1 kW heat lamps and calf jackets were tested in a randomised controlled trial. While calf jackets had no significant effect on growth rates, the use of 1 kW heat lamps was associated with improved growth rates in young calves

Background

The effective management of calves is one of the most important areas on dairy farms and can have substantial impacts in terms of health, welfare and productivity. While there are many potential factors associated with calf health and performance, it is important for vets and farmers to target improvements in management that are likely to result in both having the largest positive impact on calf performance and being applicable to the majority of farms.

This PhD aimed to identify key management factors associated with key calf performance outcomes and test these factors as a randomised controlled trial (RCT).

Aims of the study

The aims of this research are to identify key factors associated with health and productivity outcomes in preweaning calves using statistical learning techniques, which would then be tested as an RCT to demonstrate effectiveness.

What we did

Data were collected from a national cattle database to calculate mortality rates in calves and identify factors associated with mortality rates.

To identify factors associated with morbidity and growth rates, 60 dairy farms were recruited across Britain, and statistical learning techniques were utilised to identify factors associated with health and performance outcomes.

These factors were utilised to create a calf health plan which was subsequently tested as an RCT.

To further elucidate associations between temperature and growth rates, an RCT was conducted where calves would either receive a calf jacket, 1 kW heat lamp, both jacket and lamp, or no intervention.

Results

Breed type, sex, the month of birth and environmental temperature were associated with calf mortality rates at a national level.

Key factors associated with health and production outcomes for calves on dairy farms were identified, largely focusing on stocking demographics, milk/colostrum feeding practices, and both environmental hygiene and temperature.

An evidence-based calf health plan including these factors was tested as an RCT and shown to improve growth, mortality and diarrhoea rates.

1 kW heat lamps and calf jackets were tested in a randomised controlled trial, and while calf jackets had no significant effect on growth rates, the use of 1 kW heat lamps was associated with increased growth rates.

Outcomes

While there are many potential factors associated with calf health and production outcomes, this research has identified several management factors likely to be associated with key calf performance outcomes. These factors largely revolve around milk feeding, environment temperatures and the hygiene management practices of colostrum equipment and calf housing.

By testing key management factors identified in this thesis as a calf health plan in a randomised controlled setting, it was shown that the implementation of points from this plan is likely to improve the growth rates and decrease morbidity and mortality rates of calves on dairy farms.

The effect of environmental temperatures has been further tested, and the provision of supplementary heat source in the form of a 1 kW heat lamp has been shown to improve growth rates in a randomised controlled trial, further highlighting the importance of environmental temperature for young calves.

A number of farmer and vet focused tools have been created based on this research, and the tools, health plan and reporting framework are all available through the University of Nottingham Herd Health Toolkit (**nottingham.ac.uk/herdhealthtoolkit**).

Optimising heifer grazing

Robert Patterson, Steven Morrison, Katerina Theodoridou, Agri-food and Biosciences Institute, Northern Ireland

Key messages

- Weight and body condition score of the heifer entering the milking herd will affect first and subsequent lactation potential
- Cost of maintaining the pregnant heifer decreased by £1.75 for every extra day at grass

Background

Replacement rearing is a significant cost, yet one of the most commonly overlooked elements of the dairying system. With the average total cost of rearing at £1,819, or >6 ppl of milk produced, optimising heifer-rearing practices to be repaid through higher milk production and a longer productive life is important.

Improvement of rearing practices is an ongoing process, as there is always room for improvement. However, one way of improving is to better utilise grazing systems for youngstock.

Well-managed grass is the most cost-effective feedstuff for ruminants, and it is possible to get high youngstock performance levels, and development on grazing is a good way to reduce costs. Underutilisation of grass by youngstock leads to:

- Failure to meet target liveweight/ages
- Additional costs
- Sward deterioration
- Increased GHG emissions

Aims of the study

The aim of this study was to provide a better understanding of the role and potential of grazed grass within heifer-rearing systems.

- Consider the strengths and weaknesses of grazing systems and practices
- Address the weakness through incorporating precision technologies, e.g. remote concentrate-feeding systems and the possibility of weighing remotely (CIEL Investment)
- Establish the optimum pasture allowance for replacement heifers in order to both optimise animal performance and pasture growth and utilisation
- Develop grazing wedges for grazing dairy heifer replacements
- Better understand grazing strategies for heifers and how best to meet targets, leading to increased efficiencies and profits
- Improve rearing efficiency to enable heifers to fulfil their genetic potential will also directly impact sustainability and profitability

What we did

To determine the optimum pasture allowance, stocking rate and energy intake, 72 heifers were given pasture allowance for three different body weights:

- 1.8%
- 2.4%
- 3%

The pasture was measured on a complete body weight basis and was allocated on the basis of 100% utilisation. Heifers were weighed every fortnight.

Results

Pasture allowance consistently had a significant effect on:

- Herbage intake
- Live weight performance
- Grass utilisation
- Land area required

Pasture requirement decreased with the second grazing season. In maiden heifers the optimal liveweight seen was 3%, and 2.4% for in-calf heifers.

Outcomes

Grass has an important role to play in heifer rearing systems but each system must be farm specific. Time and energy invested in heifer rearing systems at grass will provide a return on investment.

Preventing respiratory disease in calves

David Bell, Marie Haskell, Scotland's Rural College

Key messages

- The more time that calves are exposed to temperatures below their lower critical temperature at a very young age (within the first 6–14 days of life), the poorer the performance that can be achieved in terms of daily liveweight gain
- Calves show an aversion to an increasing wind speed, so it is important to protect them from draughts
- Calves provide another source of particles and bacteria into the housing environment, so think about stocking rates within calf housing

Background

One of the main causes of ill health and death among calves is respiratory disease. The interaction of calf management, disease-causing bacteria and viruses and the calf environment can lead to an outbreak of disease.

The housing environment can affect disease levels as well as overall performance in calves. An important aspect of calf housing is to have good ventilation. However, there are challenges in providing adequate airflow for good respiratory health while preventing cold stress or exposure to wet conditions.

All the studies presented in this report were conducted at SRUC Dairy Research & Innovation Centre, Crichton Royal Farm, Dumfries, Scotland and used calves sourced from the on-site dairy herd.

Aims of the study

1. To assess the use of thermal imaging to measure core body temperature in calves (thermal imaging).
2. To assess the effects of climatic conditions on the behavioural response of the pre-weaned calf (behavioural response to air temperature and wind speed) as well as the performance of the calf in terms of daily liveweight gain as a measure of growth (calf performance and environment).
3. To examine the effect of a specific management decision, such a provision of bedding material of varying quality, on the quality of the air in calf housing (air quality).

What we did

Calves received four litres of thawed pasteurised, quality-tested colostrum at birth via an oesophageal tube and were placed in a straw bedded individual hutch. Once deemed strong and healthy enough, calves were transferred into a group housing igloo pen at between 6 and 14 days old. Each group housing igloo pen consisted of 14 calves (a mixture of dairy and dairy-beef crosses and male and female calves). Calves were fed via an automatic milk feeder while in the group housing igloo pens and had seven litres available daily.

A test arena for exposure to different temperature conditions and wind speeds using pedestal fans was created, with nine possible temperature/wind speed combinations. Calves had a rectal temperature taken daily using a digital thermometer and a thermal image of the eye (medial canthus of the left eye has been shown to be a proxy measure for core temperature, Childs et al., 2012).

After two familiarisation sessions, the calf was positioned in the test pen to face the fan. The test session ran for 20 minutes, and calf movement and behaviour were recorded on a video camera. Bacterial and particulate counts were also recorded to determine changes with exposure to different temperature conditions.

The following reactive behaviours were recorded: ear flicking, tail flicking, head shakes, whole body shakes, head/ear rubbing and self-grooming. The proportion of time spent in each of the two sections (test pen or shelter pen) was also calculated. Each calf was tested only once in a 24-hour period.

Results

Relationship between thermal image temperature and rectal temperature

A comparison of the mean rectal temperature by calf sex showed that the rectal temperature of male calves was on average 0.2°C higher than female calves.

Climate and diet variables

Air temperatures during data collection ranged from -0.8°–22.6°C, with wind speed ranging from 0.0 m/s to 2.3 m/s. Relative humidity ranged from 49–100%, and from the calculation, water vapour density (WVD) ranged from 3.8–15.7 g/m^3. Regardless of the sex of the calf, the consumption of reconstituted milk replacer ranged from 0.0 l/d to 15.2 l/d. The mean consumption of the reconstituted milk replacer by the male calves was 6.1 l/d and 5.1 l/d for the female calves.

Behavioural response to wind speed

As the wind speed increased, calves spent a smaller proportion of their time in the test pen (68% for 1 m/s and 44% for 3.3 m/s) and took less time to move between the test pen and shelter pen for the first time (540.2s for 0 m/s, 462.4s for 1 m/s and 237s for 3.3 m/s).

The total number of behavioural reactions from the calves in the test pen also increased. Calves took less time to display any of the behavioural reactions as the wind speed increased.

Behavioural response to air temperature

There was no significant effect of air temperature on any of the dependent variables when wind speed was included in the model. The results show that there is little evidence to suggest that temperature alone was affecting the behaviour of the calf.

Outcomes

A weak association between the rectal temperature and the temperature obtained from thermal imaging of the area surrounding the inner eye was found.

Calves showed an aversion to increasing wind speed and that there was no significant effect of air temperature on any of the behavioural measures.

A high period of exposure to temperatures below the lower critical temperature for calves had a significant effect on the daily liveweight gain.

Control of cryptosporidiosis in calves

Key messages

- Using a cost analysis specific to the study farm, a calf with severe clinical cryptosporidiosis could be worth £100 less on average than a calf with no clinical disease
- Effective cleaning and disinfection using hydrogen peroxide-based disinfectant is important to prevent infection
- Rabbits and pheasants can carry genotypes, and so effective rodent control is an essential preventative

Hannah Shaw, Moredun Research Institute

Background

Cryptosporidium parvum infection, the cause of clinical cryptosporidiosis in neonatal calves and lambs, is a significant source of economic loss to the dairy, beef and sheep industries.

In recent years, infection with this parasite has been the most commonly diagnosed cause of disease and death in neonatal calves in the UK. There is no vaccine available that helps prevent infection or disease caused by *C. parvum*, and there is only one licensed treatment for calves, but it cannot be given to affected animals. The drug needs to be given before animals get sick. A further challenge for the treatment is that it needs to be given orally on seven consecutive days, which makes it difficult for the industry to manage.

Aims of the study

Develop informed and improved control strategies that minimise the impact of *C. parvum* infection in calves that are relevant for both the beef and the dairy industries.

What we did

How important are adult cattle in the transmission of *C. parvum* to naive calves?

Previous work identified that adult cattle might play a much more significant role in the transmission cycle of the parasite than previously thought. However, these data were generated from studies on a single dairy farm. Therefore, this study involved looking at several beef and dairy farms during calving seasons to see if these results could be confirmed for other farms.

How important is environmental contamination as a risk for cryptosporidiosis in calves?

Calves become infected with *C. parvum* within the first few days of their lives, and routes of infection, other than from direct contact with their dams, may involve environmental contamination. This environmental contamination may consist of poorly cleaned and disinfected cow sheds, contaminated fields, contaminated drinking water, contact with infected calves or their faeces. Other sources could be wildlife and rodents. We established a broad sampling regime on farms with known *C. parvum* problems to establish the most common route of infection for calves.

Can timely colostrum uptake reduce the risk of clinical cryptosporidiosis?

We measured specific antibody responses, towards *C. parvum* antigens, within these sera and have correlated these results to the disease scores. *C. parvum* specific antibodies present in the calf sera before challenge will be colostrum derived, and these antibodies will confer protection from disease.

Does clinical cryptosporidiosis in calves affect long-term health and weight gain of affected animals?

We monitored cohorts of beef calves during the first weeks of their lives, generated detailed health scores focusing on *C. parvum* infection, and have correlated these data to weight gain and infection with other pathogens between *C. parvum* infection and slaughter.

This study will provide evidence of if, and how, severe *C. parvum* infection will affect calf productivity right up to slaughter.

Best farming practices and dissemination of findings to the farming community:

We worked with farmer focus groups in different regions of the UK (north of Scotland, south of Scotland, north of England, south of England and Wales) to discuss farmers' attitudes to prevention and control of cryptosporidiosis. This focused on current farm management strategies and how they can be improved. As part of these discussions, we also investigated the use and efficacy of commercially available disinfectants in conjunction with lab-based efficacy data.

Results

Transmission of *C. parvum*

- Calves are predominantly infected with the species *C. parvum*, which is also present in adult cattle
- Adult dairy cattle on the studied farm are unlikely to play a major role in *C. parvum* transmission
- Rabbits and pheasants can carry zoonotic genotypes of *C. parvum*, including those which infect calves

Production impacts of cryptosporidiosis

- Calves with severe cryptosporidiosis in the first few weeks of life are significantly smaller at 6 months of age than calves which had no clinical signs of disease
- The difference in weight occurs in the first month of life, and these calves failed to catch up over a 6-month period
- Calves with mid-range disease still suffered a reduction in growth

Disinfection

- Hydrogen peroxide-based disinfectants are the most effective at inactivating *C. parvum*
- This disinfectant must always be made up fresh and according to the manufacturer's guidelines
- A dirty environment reduces disinfectant efficacy and so the pen must be cleaned properly prior to disinfection

Outcomes

C. parvum is both costly and a risk to animal and public health. It is also resistant to many commonly used disinfectants, and this work shows that hydrogen peroxide-based products are the most effective. These disinfectants must be made up to the correct dilution and all organic matter removed for them to be at their most effective.

Developing new soil health indicators

Soil Biology and Soil Health Research Partnership 2017–2021; Elizabeth Stockdale, NIAB; Anne Bhogal, ADAS; Paul Hargreaves, SRUC

Key messages

- Soils have a range of inherent properties, texture, depth and stoniness; this soil character determines both the yield potential and many of the environmental risks for any site
- Interventions through fertiliser, manures, drainage, species/mixture choice and grazing management then interact to determine the 'health' of the soil
- A combination of in-field and laboratory measures can be used to give a simple soil health check-up; the results can help to identify the key constraints to production and possible routes to soil improvement
- Better soil health starts with what you want to know; what's going to help you manage the farm better. So, can you identify 10 places across the farm that might give you that information? Set up a plan to evaluate soil health in those places once every three to five years
- You can't replace good soil husbandry with inputs. The best soil husbandry is site- and season-specific, where each action is informed by observation

Background

Soils have a range of inherent properties, texture, depth and stoniness; this soil character determines both the yield potential and many of the environmental risks for any site. Interventions through fertiliser, manures, drainage, species/mixture choice and grazing management then interact to determine the 'health' of the soil. A healthy soil can sustain, in the long-term, crop and livestock productivity, and maintain or enhance environmental benefits.

Farmers and their advisors have been using tools to assess soil nutrient supply and/or soil compaction for many years. In recent years, interest in soil health has increased, and a range of indicators for soil biology have been developed. These indicators, however, often have not been produced in parallel with the necessary guidance and tools to allow them to be used routinely on farm.

Aims of the study

The Soil Biology and Soil Health Partnership has delivered a five-year programme that aims to improve on-farm understanding of soil health. It did this by bringing together current academic and industry knowledge to share with farmers and by developing and validating indicators of soil biology and health in research trials and on farms. The programme consists of a series of interlinked projects that brought together new cutting-edge research with on-farm evaluation. The partnership worked closely with farmers, growers and advisers to draw together and build on their knowledge and experience to create accessible guidance and tools to help improve soil health.

What we did

One key aspect of the partnership work was the development of the soil health scorecard approach. This builds on the fundamental understanding of the interactions governing soil health – physical, chemical and biological – together with the practical constraints of measurement routinely on farm. A logical sieve approach was used at first to reduce the list of 45 potential indicators to 8 (Visual assessment of soil structure (VESS), pH, routine nutrients (phosphorus, potassium and magnesium), organic matter, earthworm, microbial activity) for evaluation. Stakeholders helped to develop the 'traffic light' system to provide a visual overview of the status of each indicator. Soil health monitoring from existing medium- and long-term trials and on farm was used in parallel to validate and optimise the scorecard and to evaluate the overall approach.

Results

The partnership evaluated the soil health scorecard in long-term experiments where soil-improving measures such as manure additions were being compared. The soil health scorecard was able to distinguish the impacts of slurry (a good source of nutrients with a small benefit for soil organic matter) from those of farmyard manures (a good source of nutrients with a small liming effect, increase in soil organic matter and soil microbial activity).

Over 70 farmers volunteered to be part of eight groups around the UK covering a range of farming systems, climates and soil types. They tested and developed the scorecard approach with the partnership team since autumn 2018. The farmers felt that although the autumn window for sampling was not ideal, the sampling and recording approach required is not considered onerous and can be fitted into the busy autumn work schedule by most farmers in most years.

The presentation of data in the soil health scorecard format was valued by the farmer groups. Most importantly, in the discussion groups, the scorecards supported interesting conversations

about different management systems and their impact on soil health and wider production and environmental outcomes. Farmers found it useful to revisit the basics of pH, drainage, and organic matter addition – alongside discussions about the latest monitoring or application

Table 3. Example scorecard for Harper Adams University trial site

Attribute*	Control	FYM (23 yrs)	Slurry (23 yrs)	Green compost (13 yrs)	Green/food compost (6 yrs)	Food-based digestate (9 yrs)
SOM (%)**	3.0	4.1	3.6	4.0	3.7	3.4
pH **	6.4	7.0	6.4	7.0	6.2	6.5
Ext. P (mg/l)**	56	73	53	60	59	65
Ext. K (mg/l)**	80	311	194	187	140	167
Ext. Mg (mg/l)**	44	87	75	63	66	48
VESS score	2	2	2	1	2	2
Earthworms (Number/pit)	11	13	9	11	9	13

Investigate

Monitor

No action needed

*SOM: Soil Organic Matter – comparison to 'typical' levels for the soil type and climate; Partnership project 2 **ahdb.org.uk/greatsoils**
Ext. P, K & Mg: Extractable Phosphorus, Potassium and Magnesium; See '*The Nutrient Management Guide - RB209*' for specific crop advice, **ahdb.org.uk/nutrient-management-guide-rb209**
VESS: Visual Evaluation of Soil Structure – limiting layer score; **sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure**
Earthworms: total number of adults and juveniles; >8/pit = 'active' population for arable or ley/arable soils; Partnership project 2 **ahdb.org.uk/greatsoils**
**Attributes that showed a statistically significant difference between treatments (P<0.05)

technologies. In particular, the scorecard identifies areas where improvement can be made through management, or where more detailed assessments or more regular monitoring is needed to address any problems.

Outcomes

Just knowing some numbers about soil and even having an integrated assessment of physical, chemical and biological properties with comparison to relevant benchmarks won't improve soil health. The best soil husbandry is always site- and season-specific; there is no simple recipe of inputs, and each action needs to be informed by observation. An essential step comes before you collect any data. Better soil health starts with what you want to know; what's going to help you manage the farm better. So, can you identify 10–15 places across the farm that might give you that information? Then if you set up a plan to evaluate soil health in those places once every three to five years using the soil health scorecard, you will be able to monitor the impacts of your management and identify targeted steps to maintain your own soil health.

Extra information

AHDB have a number of practical resources to help understand soil management. These include hard copy publications which can be ordered, such as Principles of soil management, alongside web pages and informative videos. These can all be found at **ahdb.org.uk/greatsoils**

The research case study, Testing the effect of organic material additions on soil health, is available at **ahdb.org.uk/knowledge-library/research-case-study-testing-the-effect-of-organic-material-additions-on-soil-health**

Clamp silage slippage

Dr. Dave R. Davies, Silage Solutions

Key messages

The single most important factor affecting silage slippage was inconsistent consolidation during filling. To overcome this:

- Fill the clamp in layers of the same depth. Depth is determined by grass DM % – 28% DM requires 15 cm depth and <25% DM requires 25 cm depth
- Consolidate evenly for every load
- Adjust chop length to the DM % of the grass – use the hand squeeze method

Background

Clamp silage slippage occurs when the ensiled forage, usually grass, slips. Slip can occur:

- Within days of completing silage harvest
- At a later date while the clamp is still sealed
- During feed-out when a good vertical, clean, feed-out face cannot be maintained

The portion of silage at the front of the clamp slips forward, often by a few metres, which leaves a gap further back in the silage mass. Often, the sheeting is stretched and/or torn, which allows air to enter and causes both secondary fermentation and aerobic spoilage.

This fermentation and spoilage:

- Reduces the quality of silage
- Increases silage losses
- Reduces palatability
- Decreases animals' dry matter intake (DMI) of the silage

On many farms, the slipped silage will remain in place until feed-out past the slip zone. Efforts to fix the clamp face can cause a second slippage, and this process is repeated until the entirety of the clamp has been fed.

Aims of the study

The aim of the project was to investigate whether farmers might benefit from new advice during harvesting, clamp filling and feed-out, which could reduce the risks of silage slippage.

Outcomes

The results show that consolidation during clamp filling has the most impact on clamp silage slippage. Preventing clamp slippage is likely to improve silage quality, reduce losses, and improve animal intakes.

The key messages are to focus on achieving an even consolidation across the clamp and tailor the silage management to the DM % of the grass.

Extra information

More information on this study can be found at **ahdb.org.uk/clamp-silage-slippage**, with a webinar on clamp slippage and how to avoid it available at **ahdb.org.uk/webinar-clamp-silage-slippage-how-to-try-and-avoid-slippage-this-season** on the AHDB website.

Recommended grass and clover list

Key messages

- Using the latest grass and clover varieties can increase nutrient use efficiency and improve sward quality and yield
- The Recommended Grass and Clover List (RGCL) outlines the top varieties for performance and disease resistance suited to GB conditions
- Select companion grasses carefully, depending on the required clover levels
- The current RGCL protocols are applicable for lower-input conditions
- The RGCL online tool can be used to identify suitable varieties

Background

Low-input systems rely on good-quality sward to maintain production; therefore, improving sward quality and yield is important. Currently, genetic potential is explored by testing varieties under high nutrient inputs, but little is known about how varieties perform under lower nutrient conditions.

Aims of the study

The aim of this study was to evaluate the applicability of the RGCL to lower-input systems and assess how clover types performed alongside different grass varieties.

What we did

Over three years, plots of rye-grass or clover were sown at three sites (Devon, Shropshire and Yorkshire) and managed under silage and simulated grazing protocols. Trials were conducted throughout 2015.

Rye-grass

Six perennial rye-grasses (PRG), three tetraploid, three diploid, were managed under three rates of nitrogen application:

- 400 kg nitrogen/ha
- 200 kg nitrogen/ha
- 100 kg nitrogen/ha

Clover

Two medium-leaf white clover varieties were sown in a mixture with either PRG, cocksfoot or timothy. Plots received 200 kg nitrogen/ha.

Results

Rye-grass

Under silage management, there was an average 23 kg DM grass response to each kilogram of nitrogen applied (Figure 15). Initial analysis shows that there is no significant interaction between nitrogen input and the varieties, with all six varieties increasing in yield as nitrogen application rate increased. This shows that the RGCL system is representative of lower-fertiliser systems.

PRG varieties were ranked on a 1–6 scale on their total annual silage yield when grown under different applications of nitrogen (Table 4).

Clover

The contribution of clover varied between grass species and accounted for 31–58.3% of the total annual yield (Figure 16). The overriding factor that dictated the clover patterns was the growth habits of the different grass species in the same sward. When white clover was established with late-heading timothy, the clover contribution was highest, at 46%.

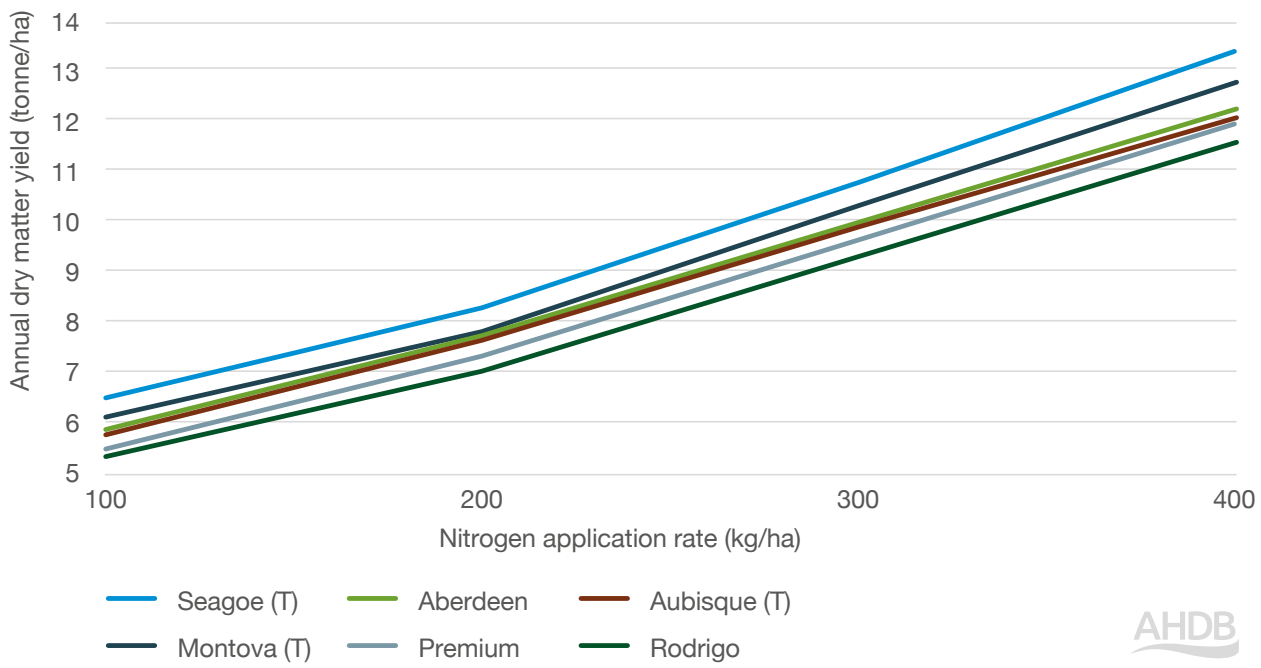


Figure 16. Annual DM yield of six PRG varieties grown under three nitrogen application rates

Table 4. PRG varieties ranked according to total annual silage yield under varying applications of nitrogen

PRG ranking	N fertilisation regime (kg N/ha)		
	100	200	400
1	Seagoe (T)	Seagoe (T)	Seagoe (T)
2	Aubisque (T)	Aubisque (T)	Aubisque (T)
3	Rodrigo	Rodrigo	Rodrigo
4	Premium	Abergreen	Abergreen
5	Abergreen	Premium	Premium
6	Montova (T)	Montova (T)	Montova (T)

(T) = tetraploid cultivar. All others diploid

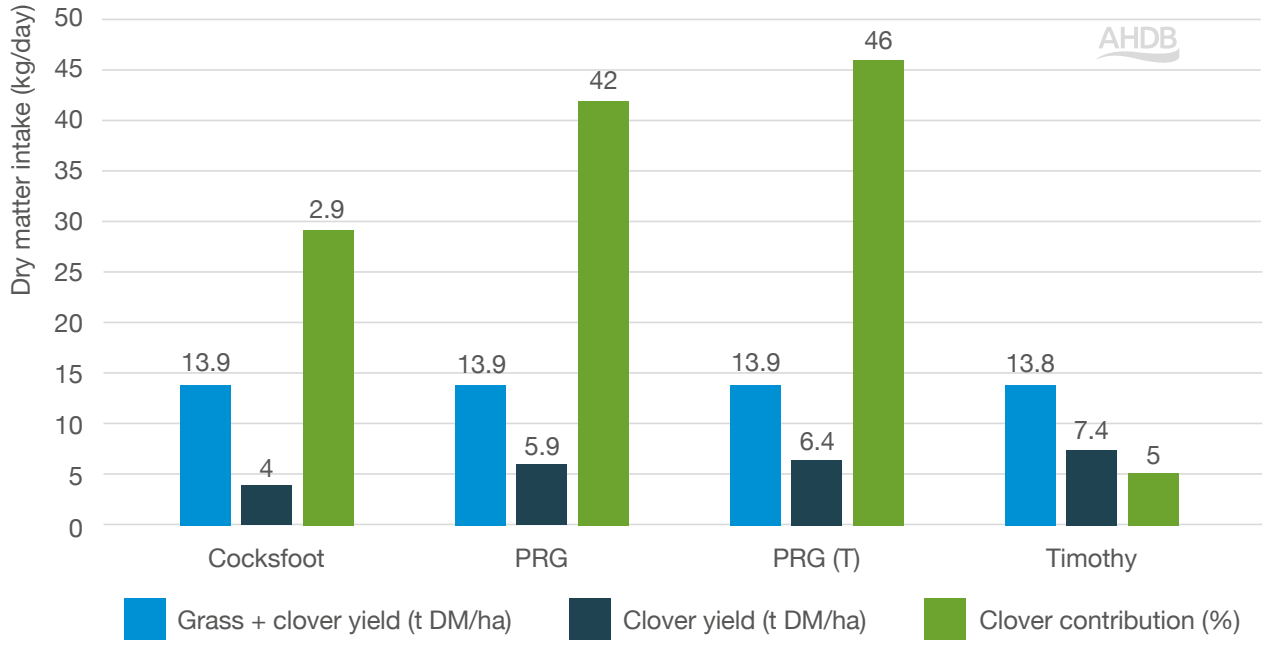


Figure 17. Impact of companion grass on white clover yield and contribution under silage management

Outcomes

The RGCL outlines the top varieties of grasses and clovers for performance and disease resistance that are suited to GB farms. However, when using the RGCL, it is important to choose the companion grasses carefully to suit the required clover levels in the field, as some companion grasses will limit the growth of clover and its contribution to the sward. The current RGCL protocols and online tool are suitable to be applied to low-nutrient-input systems, where using the correct grass and clover varieties can improve sward quality and yield while increasing nitrogen-fertiliser-use efficiency.

Extra information

The online RGCL tool can be used to identify suitable varieties of grass and clover. Find it at **ahdb.org.uk/recommended-grass-and-clover-lists**

Should Utilisable Metabolisable Energy (UME) make a comeback?

Siwan Howatson, AHDB; Prof. Liam Sinclair, Harper Adams University

Key messages

- Majority of British dairy farmers are aiming to improve pasture utilisation, and there is a potential for increasing grass production by 2 t DM/ha and utilisation by 14% to drive efficiency further
- Majority of farmers see MFF as the most useful grassland KPI to improve grass and forage productivity
- There is no relationship between grassland KPIs or between the KPIs and calving pattern
- Promoting the benefits of UME as a grassland KPI could encourage further improvements in grassland management through focusing on improving utilisation

Background

Grass production and utilisation are below their potential on British dairy farms. The use of grassland key performance indicators (KPIs) could play a vital role in accurately evaluating pasture efficiency, improving utilisation and highlighting key areas for further improvement.

Production of grazing systems depend on the yield of utilisable energy from pasture, and in past research, UME, expressed in Gigajoules (GJ), was commonly used to assess the effectiveness of pasture-based systems of utilising pasture. The advantage of UME over other grasslands KPIs such as Milk from Forage (MFF) is that it provides an overall guide to the effectiveness of grassland use and gives a basis for diagnosing reasons for low output and pointers to remedies. As reported by Forbes et al. (1980), the UME system provides a method for assessing the energy requirement of livestock and describing the energy value of home-grown and purchased forage and feed.

Aims of the study

This study aimed to identify and understand the relationship between grassland KPIs, their relation to calving patterns, and whether British dairy farmers view grassland KPIs as a useful tool for improving pasture utilisation.

What we did

For the first part of this study, a survey was used to gather data on grass and forage production and benchmarking tools used on British dairy farms.

The second part of this study focused on collecting data from British dairy farms to calculate grassland KPIs, including UME, MFF, Milk from Grazed Grass, and grass and forage utilisation. From these calculations, evaluation was carried out on the relation between the grassland KPIs and their relation to calving patterns.

Outcomes

The current study highlights that British dairy farmers are aiming to improve pasture utilisation, while it demonstrates a potential for increasing grass production by 2 t DM/ha and utilisation by 14% to drive efficiency further. The results also highlight that dairy farmers perceived grass and home-grown forage as important to their farming system and regarded MFF as a grassland KPI to improve grass and forage productivity. Promoting the benefits of UME as a grassland KPI could encourage further improvements in grassland management through focusing on improving utilisation. Future work to determine UME output per field would provide greater insight into opportunities to further improve grassland production and utilisation.

Over-supplementing heifers with copper

Dr. James McCaughern, Dr. Sandy Mackenzie and Prof. Liam Sinclair, Harper Adams University

Key messages

- Feeding level of copper should not exceed the required amount
- Avoiding over-feeding copper will directly benefit dairy cow health, performance and welfare. This will be reflected in a higher milk yield (particularly in early lactation) and improved fertility, which will increase farm profitability
- Overall, the benefits from avoiding over-feeding copper could be between £28.25 and £64/cow. For a 150-cow dairy herd, the potential benefit could be between £4,000 and £9,500 per year

Background

Copper (Cu) is an essential trace element required for the function of over 300 different proteins that influence dairy cow fertility, health and performance. Most research to date has focused on situations where there is a dietary deficiency of copper, or more commonly where copper availability is reduced by the action of antagonists such as sulfur and molybdenum. However, most dairy farms in the UK are feeding between two and three times the recommended dietary concentration of 11 mg/kg DM, and around 38% of cattle at slaughter have liver copper concentrations that are either very high or toxic. Over-feeding copper can result in toxicity and death, but in the absence of mortality there may be negative effects on health and performance. There have, however, been no long-term studies investigating the effect of over-feeding of copper during the rearing period and into lactation on the health, performance and copper status of dairy cattle.

There is a belief among some that it is better to over-feed copper 'just in case'. It has been suggested that high dietary starch concentrations and/or a low rumen pH may increase copper availability in dairy cattle, but currently this is not included in ration formulation.

Aims of the study

- Determine the long-term effects of over-feeding copper during rearing and lactation on the performance, health and fertility in dairy cattle (studies one and two)
- Determine the effect of dietary starch concentration on rumen pH and the availability of copper, animal performance and health (study three), with a view to improving the accuracy of diet formulation

What we did

The project consisted of three controlled studies:

Study one: The effect of level of copper supplementation from 4 to 22 months of age on the performance, health and indicators of copper status in dairy heifers.

Eighty Holstein-Friesian dairy heifers that were 4.1 months of age were paired and allocated to one of two treatments: Control (C): Basal ration containing 15 mg Cu/kg DM or High (H): Basal ration containing 15 mg Cu/kg DM + CuO bolus releasing 15 mg Cu/kg DM. A copper oxide rumen bolus was provided to heifers in H to result in a total dietary copper concentration that was similar to the mean value reported on UK dairy farms. Both animals within a pair had the same husbandry and environmental conditions when housed and grazing. Blood samples were collected bi-monthly, and liver biopsy samples were taken at 7 and 13 months of age and 6 weeks before calving. Heifers were weighed and condition scored fortnightly, and fertility was monitored from first oestrus to conception.

Study two: The performance and health over the first 14 weeks of lactation in heifers that had received C or H in study one.

Once the heifers had calved, they received the same basic ration containing approximately 15 mg Cu/kg DM, with animals on H given additional copper via copper oxide boluses. Milk yield was recorded at each milking, with samples taken fortnightly for analysis. Individual intake was recorded daily. Blood samples were collected over the 14-week feeding period, and a liver biopsy was collected at the end of the study.

Study three: The effect of dietary starch concentration and the inclusion of antagonists to reduce copper availability.

Using 60 early lactation dairy cows, the animals were fed a total mixed ration that was altered, so it contained either a low (150 g/kg DM) or high (230 g/kg DM) starch concentration. Cows also received either no additional or added sulphur and molybdenum. The milk yield of each cow was recorded at each milking, with samples taken on a fortnightly basis for analysis. Blood samples were collected at regular intervals during the study. Liver samples were collected at the start and end of the study.

Outcomes

The key conclusions from the three studies are:

- Over-feeding during rearing and lactation causes liver damage and reduces early lactation milk yield and conception rates
- Copper feeding levels should be based on an analysis of the forages fed. One person should be responsible for mineral nutrition, and they should include the contribution from all sources (e.g. free access licks or blocks, forages and other sources)

- In situations where antagonists to copper are high, increased copper feeding rates are required, but this must be based on a calculated amount
- High starch diets that reduce rumen pH require less copper than current recommendations, as copper is more available. However, predicting the effect of diet on rumen pH is difficult
- It is not possible to visually detect animals that are being over-fed copper as they will look and grow well. Plasma copper concentrations are a very poor indicator. Liver copper concentration, determined by biopsy or on culled animals, is the most useful means to assess copper status

Growing your own protein forage to reduce protein in diets and lower ammonia emissions

Prof. Liam Sinclair, Harper Adams University

Key messages

- Dry matter intake was approximately 1.6 kg/d less in cows fed the low protein diet, and feed conversion efficiency was higher
- Purchased feed cost savings of 0.5–1ppl can be achieved through lower protein diets
- Feeding less protein will significantly reduce urinary nitrogen excretion and improve nitrogen use efficiency. This will have a major effect on reducing the environmental impact of dairy farming

Background

There is considerable interest in lowering dietary crude protein (CP) concentrations and making greater use of home-grown forages in dairy cow diets due to the high and volatile costs of purchased protein feeds such as soya bean meal and the legislative requirement to reduce nitrogen (N) and ammonia output from dairy farms. Diets high in CP typically result in a low nitrogen use efficiency (NUE), with only around 25% of the nitrogen consumed by a cow being captured in milk, with the excess being excreted, particularly in the urine. Excess nitrogen in the urine is the major contributor to ammonia release from dairy farms. Some studies have reported that feeding low CP diets decreases milk yield and milk fat and protein content. However, others have shown that dietary protein levels can be lowered to around 140–150 g/kg dietary dry matter (DM) without affecting performance, health or fertility if the diets are formulated to meet the cows' metabolisable protein (MP) requirements.

Home-grown forage legumes such as lucerne and red clover are high in CP at approximately 180–200 g/kg DM and can fix nitrogen, reducing the need for artificial fertilisers. However, the protein in legume silages is rapidly released in the rumen, which lowers the MP supply, particularly for high yielding dairy cows. Lucerne is the most popular forage legume grown globally and is more common than grass silage in North America and many areas of Europe. Intake and milk yield are typically higher in lucerne-based diets, although high inclusion rates have been shown to reduce milk yield in recent UK based studies.

Aims of the study

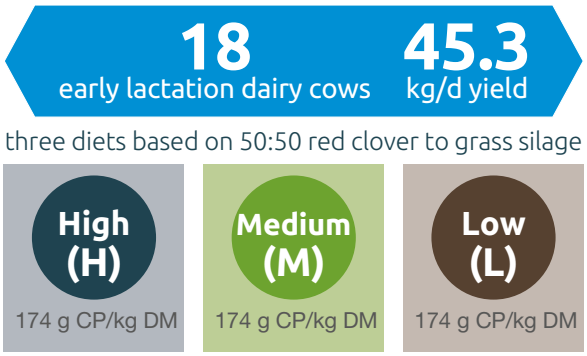
The objectives of this project were to improve the nitrogen use efficiency of dairy cows while maintaining performance and reducing purchased feed costs by feeding low protein diets based on high protein, home-grown forage legumes.

What we did

The challenge was addressed in three controlled studies (two with red clover and one lucerne silage) and a systematic review and meta-analysis of the literature.

Study one

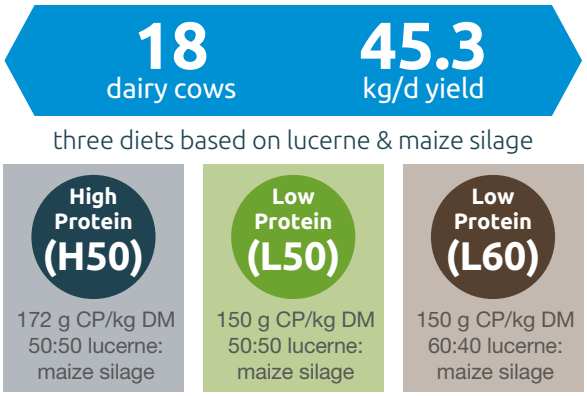
In study one, 18 early lactation Holstein-Friesian dairy cows yielding 45.3 kg/d were fed one of three diets based on 50:50 red clover to grass silage (DM basis) and one of three dietary CP levels:



Each cow received each diet in each of three periods of 28 days, with measurements undertaken in the final week of each period. During the sampling week, milk yield was recorded daily, and samples were taken for subsequent analysis. The diets were sampled daily, and faecal grab samples were collected. Blood samples were collected over two days. Liveweight and body condition score were recorded at the start and end of each period.

Study two

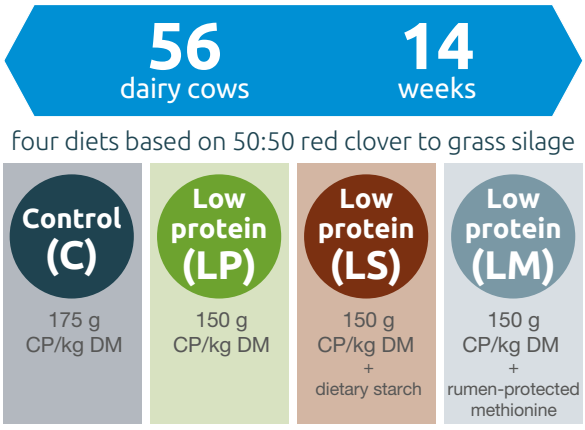
In Study two, 18 Holstein-Friesian dairy cows were fed one of three dietary treatments based on lucerne and maize silage:



Each cow received each diet in each of three periods of 28 days, with measurements undertaken in the final week of each period. During the sampling period, milk yield was recorded daily, and samples were taken for subsequent analysis. The diets were sampled daily, and faecal grab samples collected. Blood samples were collected over two days. Liveweight and body condition score were recorded at the start and end of each period.

Study three

In Study three, 56 Holstein-Friesian dairy cows were fed one of four diets for 14 weeks. All diets were based on red clover and grass silage (ratio of 1:1, DM basis), and a forage to concentrate ratio of 0.53:



The final two treatments were designed to increase microbial protein yield and improve the amino acid profile of the protein. Intake and milk yield were recorded daily, liveweight and body condition score fortnightly, and blood samples were collected during weeks 0, 4, 8 and 14. At the end of the 14-week feeding period, 20 cows (five per treatment) were restrained in stalls to allow a total collection of urine and faeces.

Study four

In Study four, a systematic review and meta-analysis of the published literature was used to investigate the effects of dietary CP concentration on the performance, metabolism and nitrogen use efficiency of dairy cows fed forage legume-based rations. A total of 36 studies with 102 treatment means were used.

Results

Study one

Reducing the CP content of a red clover silage-based diet had no effect on milk yield, milk fat or protein concentration, but DMI was approximately 1.6 kg/d less in cows fed the low CP diet, and feed conversion efficiency was higher. Compared to cows fed H or M, nitrogen excreted in the urine was lower in cows fed the low CP diet (L), and nitrogen use efficiency was higher at 30%. Dietary CP content did not affect body condition or liveweight, although the short length of the study periods made it difficult to accurately detect changes. Purchased feed costs were reduced by 1ppl in cows fed the low compared to the high crude protein diet.

Study two

Reducing dietary CP in a 50:50 (DM basis) lucerne/maize silage-based diet to 150 g/kg DM reduced DM intake by 2 kg/d and tended to reduce liveweight gain but had no effect on milk performance or diet digestibility. Reducing dietary CP also improved the efficiency of nitrogen use by 23% and reduced purchased feed costs by 0.9ppl. Compared to the Control, reducing the dietary CP in a lucerne/maize silage-based diet to 150 g/kg DM and increasing the proportion of lucerne to 60:40 (DM basis) reduced milk yield by 2 kg/cow/d and milk protein content by 0.6 g/kg milk. However, the efficiency of nitrogen use was increased by 13% and purchased feed costs were reduced by 0.5ppl. These results show that in a lucerne and maize silage-based diet, reducing the dietary CP concentration from 174 to 150 g/kg DM reduces DM intake but does not affect milk yield, fat or protein content of high yielding dairy cows and that the proportion of lucerne silage should not exceed 50% of the forage DM.

Study three

Reducing the dietary CP content from 175 to 150 g/kg DM in a red clover/grass silage-based diet did not affect DM intake, milk yield, milk composition, liveweight (LW) or BCS change over a 14-week feeding period. However, reducing CP did decrease urinary nitrogen output by 59 g/cow/d, increased nitrogen use efficiency by 20% and decreased milk and plasma urea concentrations. Purchased feed costs were also reduced by up to 1ppl, but the addition of starch or rumen-protected methionine in a low CP diet had little effect on animal performance.

Study four

A meta-analysis of the literature revealed that feeding low (145 g/kg DM) compared to high (171g kg DM) CP diets to cows receiving legume silage-based rations reduces DM intake by 0.6 kg/d, milk yield by 1.4 kg/d and milk protein content by 0.2 g/kg but increases the efficiency of nitrogen use by almost 4%, which is

reflected in lower plasma and milk urea nitrogen concentrations. Feeding very low CP levels (<140 g/kg DM) has the most negative effect on intake and performance. Milk yield is also lower in low CP diets when the inclusion rate of legume silages is high. Feeding low CP diets supplemented with rumen-protected methionine, lysine or combinations of amino acids compared to the control did not have a consistent effect on intake or milk protein content. The effect of reducing dietary CP was similar in early and mid-lactation cows or multiparous and mixed parity animals.

Outcomes

Reducing dietary protein to 150 g/kg DM in rations based on home-grown forage legumes is achievable and will not affect performance if metabolisable protein requirements are met, and the proportion of forage legume is not too high.

Feeding very low protein diets (<140 g/kg DM) is challenging and is more likely to reduce performance, although nitrogen use efficiency will be further improved.

Supplementing low protein diets with rumen-protected amino acids will increase costs but may not improve performance, although this will depend on the composition of the diet.

Purchased feed cost savings of between 0.5 to 1ppl can be achieved through lower protein diets.

Whole-farm feed efficiency on British dairy farms

Prof. Phil Garnsworthy, Emma Gregson, University of Nottingham

Key messages

- Comparisons of a farm's whole-farm feed efficiency (WFFE) against system averages and farm potential will indicate scope for improvement
- A 10% improvement in WFFE would increase gross margins by 7.4%
- If 10% of UK dairy herds adopted the recommendations, the industry could save £17.8m per year

Background

Whole-farm feed efficiency (WFFE) is defined as total milk output divided by total feed produced or purchased for all animals on the dairy farm. Feed costs represent more than 70% of the cost of milk production, and feed intake is the main driver of methane and nitrogen outputs. Improvements in feed efficiency, therefore, are generally associated with increased profits and reduced environmental impact.

Feed efficiency is usually considered only for the milking cows in a herd, but efficiency gains in milking cows might be obscured by inefficiencies in other areas. These areas could include feed used for youngstock and dry cows and feed wasted. Therefore, factors such as herd fertility, health, replacement rate, heifer rearing system, dry cow management and feed wastage may affect WFFE. Moreover, WFFE and its components might differ for production systems following different calving, grazing and feeding regimes.

Aims of the study

Quantify components of feed efficiency at the whole-herd level under a range of production and feeding systems and translate these into practical tools for use on farms. The ultimate challenge was to enable farmers to answer the following questions:

- What is the WFFE for my farm?
- How does this compare to similar farms?
- How can I improve my WFFE?
- Is it worth doing?

What we did

The challenge was addressed in four studies:

1. Standard definitions of dairy farming systems
A stakeholder group agreed that GB dairy production systems could best be classified into five systems according to the number of days cows graze, calving pattern, and feeding approach.

2. On-farm survey of British dairy farms
Twenty-one farms representing the five systems were visited quarterly for one year. Data on animal numbers, milk production and composition, feed purchases, stocking rate, grass and forage use, and youngstock rearing were collected and used to calculate WFFE.

3. Information from the Defra Farm Business Survey
Questions were added to the Farm Business Survey to provide information on farming system and physical performance, alongside the financial information routinely gathered in the survey. The survey was performed on two samples of 300 farms in two financial years.

4. Production of a calculator tool
An Excel spreadsheet was developed to calculate WFFE on a dairy farm from farmer inputs and compare WFFE with system averages and potential WFFE.

Results

There were wide ranges for WFFE within systems, but overall the range was 0.5 to 1.3.

Overall, WFFE was positively associated with stocking rate ($r=0.585$; $P=0.014$), milk yield per hectare ($r=0.759$; $P<0.001$), and milk from forage ($r=0.530$; $P=0.029$). These factors reflected forage quality and grazing management. Fertility, health, replacement rate and heifer rearing system influenced WFFE on individual farms.

Calculator tool

The results enabled the production of an interactive tool to calculate WFFE. The tool was designed to enable farmers and advisers to calculate WFFE, key drivers for specific farms, and potential WFFE for farms and systems. A research version of the tool enabled researchers to quantify relationships between parameter values and WFFE. These relationships can provide decision-support information.

Functions and features of the calculator tool are:
Calculate WFFE from farmer inputs:

- A simple, clear interface for farmers to input routine farm data
- Include standard values where farm data are missing

Compare farm WFFE with other values:

- Average WFFE for each farming system
- Theoretical potential WFFE based on animal requirements, land area, forage quality, heifer system, etc.

Provide decision support tools based on drivers:

- What is the cost/benefit of changing factors?
- Which will give the best return?

Outcomes

The project provides a practical tool for farmers to calculate WFFE for their system. This will be incorporated into the AHDB EnviroBench tool as part of a whole farm efficiency calculation.

Overfeeding and consequences: identifying best practice to reduce phosphorous losses from soil

Brad Harrison, Dr. Partha Ray, Prof. Chris Reynolds, University of Reading; Martina Dorigo, AHDB; Prof. Liam Sinclair, Harper Adams University

Key messages

- Minimising phosphorus (P) feeding to dairy cows can reduce feed costs and minimise water pollution without impairing animal performance
- Feed professionals have an important influence over phosphorous feeding practice, particularly in housed systems. Therefore, the better utilisation of feed professionals' influence to minimise phosphorous feeding is increasingly important as the number of housed dairy farming systems in GB has increased
- Phosphorous feeding strategies will differ for each farming system, and advice of a feed professional can help to ensure that diets meet requirements

Background

Globally, there has been increasing public concern about environmental pollution from livestock farming. In particular, eutrophication degrades water quality and reduces aquatic biodiversity, annually costing the UK an estimated minimum of £229m.

Eutrophication is accelerated when waterbodies are enriched with phosphorus, and a major source of phosphorous enrichment is agricultural land that has received phosphorous above the crops' requirement. In the UK and in many European countries, land application of phosphorous is indirectly regulated by limits on the application of nitrogen via manure. However, dairy cows excrete 60–80% of consumed phosphorous in faeces, and this faecal phosphorous excretion is positively correlated with dietary phosphorous intake.

Therefore, feeding more phosphorous than required to dairy cows can result in an imbalanced nitrogen: phosphorous ratio. This makes it difficult to apply manure to land based on crop nitrogen requirement. Since the phosphorous content in manure can vary, land application of manure phosphorous can be optimised via quantifying manure phosphorous to adapt mineral fertiliser phosphorous application.

However, minimising phosphorous feeding remains the optimal cost-effective approach to reduce the over-application of phosphorous to land, especially in areas with a high soil phosphorous index where farmers need to transport phosphorous-rich manure to further lands which will incur costs.

Aims of the study

Determine current phosphorous feeding practices and identify the barriers to and motivators for minimising phosphorous feeding on dairy farms, using GB dairy farming as an example of diverse systems.

What we did

Two thousand dairy farms were randomly selected and sent a copy of the survey. The questionnaire

consisted of 42 questions and collected information on farm management practices, including precision phosphorous feeding practices and farmers' attitudes towards feeding lower dietary phosphorous concentrations to dairy cows. Farms were categorised into GB region (England, Scotland and Wales), whether or not they relied on a feed professional (nutritionist, feed supplier or veterinary) and farm classification.

The five farm classifications are based on calving pattern, days of access to grazing and concentrate supplementation.

Classification 1 farms adopt spring calving and graze >274 days a year with limited supplements.

Classification 2, 3 and 4 farms adopt block or all-year-round calving with increasing use of concentrate supplement as grazing days reduce.

Classification 5 farms adopt all-year-round calving in a housed system with the greatest supplement use fed as a total mixed ration.

The questionnaire was piloted on five dairy farms and revised prior to distribution.

Key results

A total of 139 responses (126 postal and 13 online) were returned from the farmer survey with a mean herd size of 257 (range: 72–500 cows).

Seventy-two per cent of farmers did not know the phosphorous concentration in their lactating cow's diet and did not commonly adopt precision phosphorous feeding practices, indicating that cows might have been offered dietary phosphorous in excess of recommended phosphorous requirement.

Farmers' tendency to feed phosphorous in excess of recommendations increased with herd size, but so did their awareness of phosphorous pollution issues and likeliness of testing manure phosphorous.

However, 68% of farmers did not analyse manure phosphorous, indicating that mineral phosphorous fertiliser application rates were not adjusted accordingly, highlighting the risk of phosphorous being applied beyond crops' requirement.

Ninety-six per cent of farmers were willing to lower dietary phosphorous concentration, but the uncertainty of phosphorous availability in feed ingredients (30%) and concerns over reduced cow fertility (22%) were primary barriers.

The willingness to reduce dietary phosphorous concentrations was driven by the prospect of reducing environmental damage (28%) and feed costs (27%) and advice from their feed professionals (25%). Seventy per cent of farmers relied on a feed professional and had a higher tendency to analyse their forage phosphorous.

However, farmers of pasture-based systems relied less on feed professionals. Both farmers (73%) and feed advisers (68%) were unsatisfied with the amount of training on phosphorous management available.

Outcomes

- Training on phosphorous management needs to be more available, and the influence that feed professionals have over phosphorous feeding should be better utilised
- Pasture-based systems were less likely to use a feed professional compared to housed systems feeding total mixed ration
- Most dairy farmers were not aware of how much phosphorous they were feeding or how much they should be feeding to their cows and instead relied on feed professionals
- It is important to consider the type of dairy farming systems when developing precision phosphorous feeding strategies
- Farmers were willing to reduce dietary phosphorous concentrations. To facilitate judicious use of phosphorous, policymakers and research agencies should consider the following strategies:
  - Increase the availability of phosphorous management education to emphasise the benefits of precision phosphorous feeding
  - Better utilise feed professionals' influence over phosphorous feeding practices on dairy farms to promote precision phosphorous feeding practices and lower dietary phosphorous concentrations in formulated diets

Extra information

This work has been published by the journal Animal:

Harrison et al., (2021). *Phosphorus feeding practices, barriers to and motivators for minimising phosphorus feeding to dairy cows in diverse dairy farming systems.* Animal, 15 (7). 100248. ISSN 1751-7311

Evidence-based decisions to improve dairy herd fertility

Ed Hayes, Prof. Martin Green, Prof. Chris Hudson,
University of Nottingham

Key messages

- Several post-calving diseases are associated with a decrease in reproductive performance in affected cows
- Reducing levels of post-calving disease is likely to have a relatively small impact on herd-level fertility performance in most scenarios, although the impact can be larger where initial levels of disease are very high
- In many 'typical' herd scenarios, preliminary results from simulation modelling suggest that improving early lactation energy balance and measures to optimise submission rate are likely to provide bigger performance improvements compared to other factors such as control of infectious disease, improvement in herd genetics or reductions in levels of endemic disease

Background

Fertility performance is a key driver of efficiency in a dairy business, so understanding how to improve this is essential to future economic and environmental sustainability, both at individual farm and at industry wide level. Despite a very large body of research evidence on factors affecting different aspects of reproduction in dairy cows, progress in improving performance has been disappointingly slow.

In part, this is because fertility is highly multifactorial, with a very wide range of aspects of management having the potential to influence outcomes. It is very difficult for both producers and their advisors to understand which management changes or investments are most likely to have the largest impact on performance on a given unit, given that many studies look at a small subset of potential factors or a particular component of fertility performance in isolation.

Aims of the study

The first part of this project aimed to add to existing knowledge on the relationship between post-calving disease and reproduction in GB herds, using a large pre-existing dataset. The second part of the project brought together key findings from existing evidence and developed a method to evaluate which factors are most likely to be most influential on herd-level reproductive performance across different scenarios.

What we did

Data from a small subset of English and Welsh dairy herds with excellent data recording were used to explore the relationship between a variety of post-calving diseases and reproductive outcomes. This work involved developing methods to measure data quality, and statistical modelling was used to quantify associations for each individual disease and how the impact of disease on fertility changed as cows moved through lactation.

Structured literature searches were then conducted on the influence of 10 key aspects of management on reproduction, and statistical methods used to 'pool' the results of multiple studies in each area.

A simulation model representing the reproductive process was developed and used initially to put the results of the post-calving disease work into context (e.g. by comparing the predicted effect of reducing disease to that of changing milk yield or improving submission rate). Finally, the same simulation model was adapted to include scenarios for the 10 key areas in which literature was reviewed so that comparisons in predicted outcomes could be made across a wide range of potential interventions (e.g. improving early lactation energy balance vs adopting vaccination for bovine viral diarrhoea (BVD).

Results

A variety of post-calving diseases were associated with significant impairment of fertility; these relationships generally became smaller later into lactation. Ovarian cysts diagnosed at >42 DIM and endometritis were the diseases with the highest potential impacts.

Incorporating these results into the simulation model showed that, in most situations, endometritis was the disease where a reduction in rate was likely to have the largest positive effect on herd-level performance. However, the predicted impact of reducing any of the post-calving diseases was small compared to, for example, the effect of a change in 'background' submission rate.

Preliminary results from including research from other areas in the simulation model suggest that, in many 'typical' herd scenarios, focusing on improving early lactation energy balance and submission rate are likely to improve overall performance the most. However, this will be different for each farm situation, so an online decision support tool is currently in production to put the results from this work within easy reach of producers and their advisors.

Outcomes

The first part of this research provided further evidence that 'transition diseases' can reduce fertility and has provided better insight into the different ways in which these relationships change as cows move through lactation. Several of these diseases had strongly statistically significant associations with reproductive outcomes.

Simulation modelling was then used to put these results in the context of the other factors that influence herd fertility. This showed that even the diseases with the largest effect sizes were likely to make a very small impact on overall reproductive performance – for example, reducing the proportion of cows getting endometritis from 12.5% to 9% was predicted to improve herd 21-day pregnancy rate by less than 0.5%. This suggests that, in many situations, reducing post-calving disease is not likely to be the most important intervention to improve overall performance, although it may be more appropriate in herds with very high initial rates of disease. Inclusion of research evidence on other factors associated with reproduction to the simulation suggested that energy balance and heat detection will commonly be the most reliable areas to focus on to improve overall performance.

Extra information

The simulation model developed in the project has been produced to explore other relationships, such as the potential impact of changes in fertility performance on economic value. This work is ongoing.

A simple decision support tool using the simulation results is currently under development. Once complete, this will be added to the existing herd health toolkit at **nottingham.ac.uk/herdhealthtoolkit**

Reputational factors in dairy that are important to consumers: sustainability and animal welfare

Susie Stannard, AHDB

Key messages

- The dairy sector is under pressure from consumer behavioural change
- With the growth of alternatives, consumers are increasingly engaged in where their food comes from and asking difficult questions
- With health, the environment and animal welfare all being questioned, the industry needs to be prepared to demonstrate credentials in each of the above and to relook at problematic practices

Background

The Retail and Consumer Insight team at AHDB are tasked with helping levy payers and other stakeholders to understand their end consumers. Once, marketing was as simple as reminding people about the deliciousness of dairy, but now there is a clear need to understand and address more ethical reasons for behavioural change.

Aims of the study

To give an overview of which factors are really important to consumers when thinking about their dairy consumption today and tomorrow.

What we did

AHDB's Retail and Consumer Insight team buy into a range of data sources: Kantar retail and usage data using a panel of 20,000 consumers, YouGov tracker, 2,000 consumers per quarter, and various ad-hoc studies looking into reputational factors.

Results

Concerns about health, the environment and animal welfare are increasingly aiding a switch away from dairy to alternatives.

Outcomes

By exploring and monitoring the key consumer concerns industry can start putting in place strategies to address these, whether these are communication or leading to practical change.

Consumer attitudes to dairy farming

Amy Jackson, Prof. Martin Green and Prof. Jasmeet Kaler, School of Veterinary Medicine and Science, University of Nottingham; Dr. Kate Miller, School of Biosciences, University of Nottingham

Key messages

- Preferences for how dairy cows are managed and milk is produced are more diverse among the public than first appears, with socio-demographics, experiences and attitudes all playing a role
- Despite having little direct experience of cows, the public have formed strong attachments with them, 'framing' them – sometimes simultaneously – as subordinates, forces of nature, or companions
- Dairy farmers are 'framed' by the public as traditional or modernising – in both positive or negative lights, creating distrust and confusion about their care of the cow
- While fully housed or fully grazed systems are less favoured by the public, some perceive them as offering a better choice of environment or comfort in the former, and a more natural life in the latter
- There is no universal perception of an 'ideal' dairy farming system, but there are aspects that could be communicated more effectively and adaptations to systems that could improve public support of dairy farming

Background

Conflicting views between the dairy industry and the public about how dairy cows should be managed, together with an increase in the availability of alternatives to dairy foods, challenge future markets for milk producers. Members of the public are understood to value animal welfare as well as naturalness and grazing – but key questions remain. How diverse are these views, and why? What preconceptions are they based upon? And how do these preferences play out in terms of different management systems and the benefits they are seen to deliver to the cow? A better understanding of these perspectives will not only help the dairy industry to improve its communication to citizens and consumers about the social sustainability

of milk production but also offers opportunities for the industry to adapt its production systems to better meet societal expectations.

Aims of the study

This study set out to understand public perceptions and preferences around dairy cow management in UK milk production, especially in relation to dairy cow welfare. Improved understanding of these areas could not only help to adjust outward communication but could identify ways to adapt production systems to better meet societal expectations.

What we did

Quantitative and qualitative methods were used. First, a survey of over 2,000 UK citizens used Best Worst Scaling to present 17 different preferences for cow management and milk production; Hierarchical Bayesian analysis was used to develop a scaled ranking from the results, with Latent Class analysis identifying underlying groups with different preferences and characteristics.

A subset of 60 survey participants then took part in face-to-face interviews. Frame analysis first identified how participants framed the cow and the farmer, then responses to descriptions of three different management systems were analysed qualitatively using inductive thematic analysis and quantitatively using text and sentiment analysis.

Results

While health and welfare, grazing and cow comfort were equal top priorities overall in our survey, six underlying 'citizen groups' of approximately equal size were identified, each with very different preferences. These groups were also characteristically distinct in terms of a range of attitudes, experiences and socio-demographic factors.

Frame analysis of the 60 face-to-face interviews further investigated what might underlie diversity of opinion on dairy cow welfare by examining perceptions of two key factors: cow and farmer. Interviewees had strong attachments to the cow, seeing her as an enduring, mysterious force of nature or familiar companion. By contrast, the farmer was either 'traditional' and/or 'modernising' but in both positive and negative lights, leading to distrust over how well the cow is actually cared for.

Investigating how participants viewed different dairy farming systems found that keeping cows inside in the winter and outside grazing in the summer was strongly favoured as a good compromise and the 'best of both worlds', offering safety and protection from danger but also a natural environment. Fully housing or grazing cows lacked familiarity or understanding of how cows could thrive in such conditions. However, diversity of view was also apparent, with some supporting fully housed systems for offering improved choice or comfort and fully grazed systems for being altogether more natural for the cow.

Welfare
18.3%

University educated

Broad-minded and tolerant in outlook

Has visited farms

Unrestricted diet

Grazing
15.6%

Urban or suburban

Older

More traditional

Taste of milk
15.2%

High-achieving

Knowledgeable about dairy farming

Inexperienced with animals

Fair price
18.9%

Older

Traditional

Rural

Knowledgeable about dairy farming

Comfort
14.6%

Vegan or vegetarian

Consumes plant-based milk

Not university-educated

Strongly believes in a cow's 'mind'

No preference
17.2%

Male

Narrow focus on self

Inexperienced with animals and farming

Highly rates own dairy knowledge!

Figure 18. The six 'citizen' groups, identified by their top priority for dairy farming, and their likely characteristics

Outcomes

The results of this study suggest that despite simplistic headlines claiming preferred dairy farming systems, for example, that cows should graze, there is significant diversity of view and preference among the UK public. The underlying causes of this diversity could include socio-demographic, attitudinal or experiential differences or the way in which people use their memories and experiences to 'frame' cows and their care at the hands of the farmer.

While grazing is important, protection from the weather and danger such as theft or predation is also a duty of the farmer. However, here, too, there is diversity of opinion around what benefits different management systems can offer.

There is no clear universal perception of an 'ideal' dairy farming system, but there are aspects that could be communicated more effectively and adaptations to systems that could improve public support of dairy farming and better fit societal expectations.

Housing and loafing space

Jake Thompson, Prof. Chris Hudson, Dr. Jasmeet Kaler, Dr. Robert Robinson, Dr. Kathryn Woad, Nicola Eyre, Prof. Martin Green, University of Nottingham; Prof. Jon Huxley, Massey University; Jenny Gibbons, AHDB

Key messages

- There is a large variation in current housing conditions across GB dairy farms, highlighted by a range on total space allowances of 5.4–12.7 m^2 per cow and living space allowances of 0.5–6.4 m^2 per cow
- A year-long randomised controlled trial has shown that increased living space allowances:
  - Increase milk volume production by as much as 600 L per 305-day lactation in heifers
  - Change cow behaviour, with cows lying down for over one hour longer per day without any changes to the cubicles themselves
  - Increase days to conception because of a reduced conception rate
- Importantly, the costs associated with providing increased living space allowances appear to be offset by the increased productive performance of the cows

Background

A new term 'living space' was described to define the additional space available for dairy cows above a minimum baseline requirement and accounts for all areas of excess space in cubicle sheds using a set definition and method of calculation, based on discussions from an industry-led stakeholder group meeting.

Current guidelines and definitions for space measurements in dairy cow housing are ambiguous and lack scientific clarity. Guidelines for total space per cow range from 6.5 m^2 (Red Tractor Farm Assurance) to 10.5 m^2 (AHDB housing guidelines) per cow. This has caused large variation within dairy cow accommodation across GB dairy farms (range: 5.4–12.7 m^2 per cow).

This combination of current variation in housing management, alongside ambiguous definitions, recommendations and a lack of scientific literature, meant that research was urgently required to understand how current housed conditions in the UK impact dairy cow production, reproduction, behaviour and economics.

Aims of the study

The main aims of the research were:

- To quantify and define key housing areas utilised on commercial GB dairy farms
- To evaluate farmer perceptions of space allowance recommendations and the importance of loafing space
- To undertake a long-term randomised controlled trial to investigate the impact of living space on:
  - The production of housed dairy cows
  - The reproductive performance and physiology of housed dairy cows
  - The behaviour of housed dairy cows
- To evaluate the farm economics associated with providing additional living space for housed dairy cows

What we did

A year-long randomised controlled trial was undertaken in a unique, purpose-built facility, which allowed precise measurement and configuration of the housed area. All elements of the trial were conducted under Home Office licence, in accordance with government regulations.

Adult Holstein dairy cows (n = 150) were randomly allocated to a 'high' living space group (living space = 6.5 m^2, total space = 14 m^2) or 'commercial average' living space group (living space = 3 m^2, total space = 9 m^2); all other aspects of the housed infrastructure (e.g. feed-face length, lying areas) were identical between groups.

Primary data collected consisted of daily milk volumes recorded automatically from Lely Astronaut A4 milking robots, time to conception reproductive data and location data at 7-second intervals to calculate daily time budgets.

A simulation model was created to explore the economic outputs associated with the reproduction and production results of the trial to produce a possible financial return for each living space scenario.

Results

Compared to cows in the commercial average space group, cows with increased space produced more milk per 305-day lactation (primiparous cows; 12,235 L vs 11,592 L ($P<0.01$), multiparous cows 14,746 L vs 14,644 L ($P<0.01$) but took longer to conceive, 135 DIM vs 101 DIM ($P<0.05$).

In terms of underlying physiology, cows with increased living space ruminated for 15 minutes/d longer than those with less space. No differences were observed between trial groups for all other reproductive and production parameters measured.

Cows with less living space spent less time in lying (65 minutes/d) and feeding (9 minutes/d) areas and more in passageways (64 mins/d).

When these results were imputed into a simulation model, it suggested that the reduced reproductive performance was negated by increased milk volume production for cows in the high space group. The results suggest that providing more living space will be economically viable as well as offering potential for enhancement of cow welfare.

Outcomes

This is the first long-term randomised controlled trial in dairy cows to demonstrate that increased living space results in meaningful benefits in terms of milk production and behaviour of housed dairy cows. It is likely that additional living space will be of benefit to adult dairy cows, but further research is needed into the effects on longevity, reproduction and the cost-effectiveness of providing extra space. It will also be of importance to investigate how living space impacts dairy cows in different environmental conditions and management systems.

This research presents a novel term, 'living space', which has only recently been defined and published, as an important area worthy of future investigation for the dairy industry. Given the current large variation in space allowances provided to cows across GB, this should provide some evidence to help farmers decide on how to invest in improving housing and ultimately improve cow health, wellbeing and productivity.

A living space calculator tool has been developed for farmers and vets to assess the space availability within housed environments. This is available through the University of Nottingham Herd Health Toolkit (**nottingham.ac.uk/herdhealthtoolkit**).

The living space calculator provides the industry with a measurement that can be consistently quantified for all cubicle housing accommodation. This also provides evidence of the importance for the dairy industry to state total and living space allowance figures in their research trials, so that this potential confounder can be accounted for. These results will also provide a basis for how living space allowances may impact on outcomes of their studies. Furthermore, it highlights key areas for future research to help define appropriate regulations and recommendations for dairy cow housing from a strong evidence base, which is currently missing.

Extra information

This work was published and available in the Journal of Dairy Science:

Thompson et al., 2020. *Field survey to evaluate space allowances for dairy cows in Great Britain*. Journal of Dairy Science. 103, pg 3,745-3,759.

The University of Nottingham Herd Health Toolkit is available at **nottingham.ac.uk/herdhealthtoolkit**

Optimising lying comfort: designing housing to meet the needs of the dairy cow

Steven Rutter, Harper Adams University; Laura Shewbridge Carter, Marie Haskell, Scotland's Rural College; David Ball, Jenny Gibbons, AHDB

Key messages

- Cows value lying on an open lying space more than a preferred lying surface
- Cows are motivated to access an open lying space, with surface type having a minimum effect on this motivation
- When provided the same open lying space indoors and outdoors in the autumn, cows do not have a preference, nor are they motivated to go outdoors and lie down
- This research has identified features of a lying area that are important to cows and show that housed cow welfare could be improved with innovative housing design

Background

For a variety of reasons, all-year-round housing systems are increasing in practice in the UK and across Europe. However, the public perceives pasture access as positively contributing to dairy cow welfare. Additionally, cows have a preference and are motivated to gain access to pasture. This motivation is unaffected by herbage allowance and is stronger at night, when cows primarily lie down, than during the day. Therefore, it is thought that their motivation to access pasture is driven by the properties it offers cows for lying down. It is unclear what aspects of pasture are attractive to cows for lying down, such as the lying space available, the surface type or being outdoors. If the lying qualities cows value at pasture could be identified and applied to the design of indoor housing, some of the welfare

concerns around housing dairy cows could be addressed.

Aims of the study

This research aims to identify different lying qualities that cows value, which may exist at pasture but may be absent in conventional indoor housing. By identifying what aspects of a lying area cows value, it is hoped that this research could encourage new innovations in dairy cow housing design and improved housed dairy cow welfare.

What we did

This research comprised a series of three studies using preference and motivation research techniques, allowing the researchers to 'ask' cows what they wanted in a lying space.

The first study created a trade-off-preference choice to determine whether lying space or a preferred lying surface was valued more.

The second measured cow motivation to access an open lying area, using walking distance as an indicator of motivation, and was repeated using two different open surface types.

The final study measures cow preference and motivation to access an open lying area outdoors when the same open lying area was provided indoors.

Results

Cows value open lying space more than lying surface type, with cows trading lying on their preferred lying surface with a cubicle, restricting lying space, to lie down on a less preferred lying surface without a cubicle, presented as an open lying space.

Additionally, cows are motivated to access an open lying area by walking long distances for access when provided free access to cubicles. The surface type had a minimum effect on this motivation, with cows slightly more motivated to access an open straw yard than an open mattress.

When provided with the same open lying space indoors and outdoors in the autumn, cows did not show a preference for either lying area. Cows showed a low level of motivation to access the outdoor open lying area when a walking distance was implemented to access it, with cows choosing to lie down more often on the indoor open lying area, which they had free access to. Weather during this time was mild and had a minimum effect onlying times outdoors.

Outcomes

Not only do cows place a higher value on open lying space than on the surface type, but they are willing to work to gain access to open lying areas. Although surface type has an effect on motivation, this effect is limited and secondary to motivation for an open lying space. Additionally, when given access to the same open lying option indoors and outdoors, cows do not have a preference for one location over the other.

Furthermore, they are generally not willing to work to lie down outside when given free access to the same open lying option indoors.

Overall, cows showed to value an open lying area when housed, and its provision better meets the behavioural needs of housed dairy cows. With previous studies showing the importance of lying behaviour to cows, and with increased lying times having potential benefits to milk production, there are possible positive welfare and production implications of providing cows with open lying spaces when housed. Housing systems that provide cows with open lying spaces is an important factor to consider in the design of future cow housing.

Extra information

The first study in the series has been published in the Journal of Dairy Science:

Shewbridge Carter et al. (2021). *Dairy cow trade-off preference for 2 different lying qualities: Lying surface and lying space*. Journal of Dairy Science. 104, pg 862-873.

There are two videos giving extra information about the second study, 'Trial Area Layout' and 'Cow-Eye View of Raceway to Outdoors at Short Distance', published by Laura on Youtube, at **bit.ly/3EAHFSr**

Dairy bull calves

Background

The welfare of dairy cattle is a top priority for the dairy sector, and farmers take the lead to develop and enforce the highest standards on our farms. The fate of dairy bull calves is not a secret; it is actually a key focus within the industry. Approximately 30% of calves born in the dairy herd are heifers to join the milking herd. Ninety-five per cent of bull calves are expected to be reared for beef, if suitable, or sold for rose-veal. The dairy industry is proactively working on initiatives to champion calf health welfare and survival.

GB Calf Strategy update

The complex nature of the supply chain includes both the dairy and beef sectors, and underpins the need for a coordinated strategy that prioritises collaboration, communication and industry-wide buy-in. The GB Calf Strategy was introduced in 2020 to identify where there is potential for further improvement through collaboration within the supply chain. The stakeholder group, consisting of farmers, milk processors, retailers, abattoirs, markets, government representatives and experts from the allied industries (nutrition, calf rearers and genetics), have committed to rearing all calves with care and to eliminate the practice of euthanasia of calves by 2023. (Quality of life should always take precedence over lifespan.)

It is vital that the actions satisfy customer expectations, prioritise animal welfare and remain profitable at every stage of the supply chain. Collaboration will be key to delivering against these priorities.

In order to deliver on these objectives, two smaller working groups have been established, coordinated by AHDB and NFU:

- **Downstream working group**

  Focusing on farm level changes to increase the number of viable calves entering the beef supply chain. This includes guidance on rearing all calves with care, encouraging responsible breeding strategies and reviewing guidance for TB infected herds

- **Upstream working group**

  Focusing on developing market opportunities for beef from dairy. This includes better communication of market requirements, opening new supply chains, supporting research and development, and increasing bio-secure routes for TB infected herds

Extra information

The top priorities and actions of the GB calf strategy can be downloaded from the AHDB website at **ahdb.org.uk/GB-calf-strategy**, with frequently asked questions and answers available at **ahdb.org.uk/knowledge-library/gb-dairy-calf-strategy-faqs**

A webinar discussing the strategy and common problems, such as what to do if you are under TB restrictions, is available on the AHDB Dairy YouTube channel, titled **GB Dairy Calf Strategy**.

Studentships – PhD

Who	What	When	Where	Additional funding
Robert Hyde	Optimising the health and welfare of dairy and dairy cross-bred calves	Oct 19 – Aug 23	University of Nottingham	AgriFood Charities Partnership
Emma Middleton	Use of precision tech for mobility scoring to objectively measure lameness in dairy herds	Oct 19 – Aug 23	University of Nottingham	BBSRC
Bethany Griffiths	Aetiopathogenesis and genomic architecture of resistance to claw horn disruption lesions in dairy cattle	Oct 19 – Aug 23	University of Liverpool	BBSRC
Fern Baker	Modelling net carbon emissions from dairy production systems	Completion – 2023	University of Nottingham	AgriFood Charities Partnership

Research through partnership

The research reported in this booklet would not have been possible without the collaboration of industry and universities. AHDB acknowledges the contribution of the following partners to the research programme.

AB Agri

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AgriSearch NI

ADAS

Agri-Food and Biosciences Institute: AFBI

Ayrshires Cattle Society

Bangor University

Biotechnology and Biological Sciences Research Council: BBSRC

University of Bristol

Brown Swiss Cattle Society

Centre for Ecology and Hydrology: CEH

Centre for Evidence-Based Veterinary Medicine

Cattle Information Service: CIS

Dale Farm

Dairy UK

Department for Environment Food and Rural Affairs: Defra

Evidence Group: EBVC

English Guernsey Cattle Society

University of Exeter

EGenes

Harper Adams University

Holstein UK

Hybu Cig Cymru: Meat Promotion Wales

Jersey Cattle Society of the United Kingdom

Langford Trust for Animal Health and Welfare

University of Liverpool

LINK Collaborative Research

Montbeliarde UK

Moredun Research Institute: Moredun Group

NIAB TAG

National Milk Records: NMR

The University of Nottingham

Quality Meat Scotland: QMS

University of Reading

The Royal Guernsey Agricultural and Horticultural Society

Royal Jersey Agricultural and Horticultural Society

Royal Veterinary College: RVC

Dairy Shorthorns: Shorthorn Society

SRUC: Scotland's Rural College

Notes

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