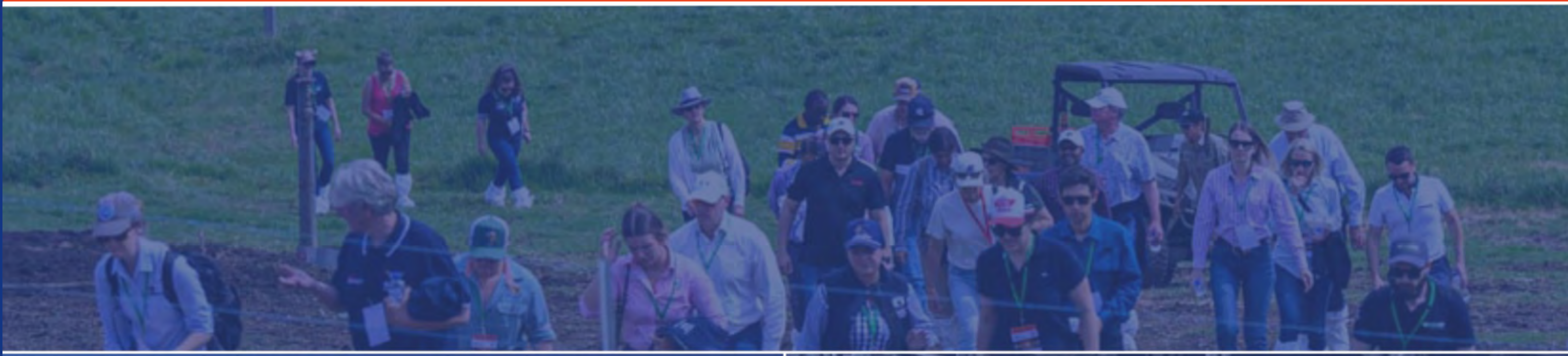
DairyUP
Unlocking potential

PROJECT OUTPUTS JOURNAL

Prepared for 2025 DRF Symposium Attendees

26th & 27th November 2025 | Wollongong, NSW



JOURNAL OF PROJECT OUTPUTS

What's inside

DairyUP
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Dairy UP has developed a new and innovative model of collaborative dairy R&D, based on four pillars: **Co-investment, Collaboration, Co-delivery, and Rejuvenation.**

Who is Dairy UP?

Dairy UP is a collaborative program led by the University of Sydney's Dairy Research Foundation, and delivered through the New South Wales

Department of Primary Industry, Scibus, Dairy Australia, and the University of Sydney.

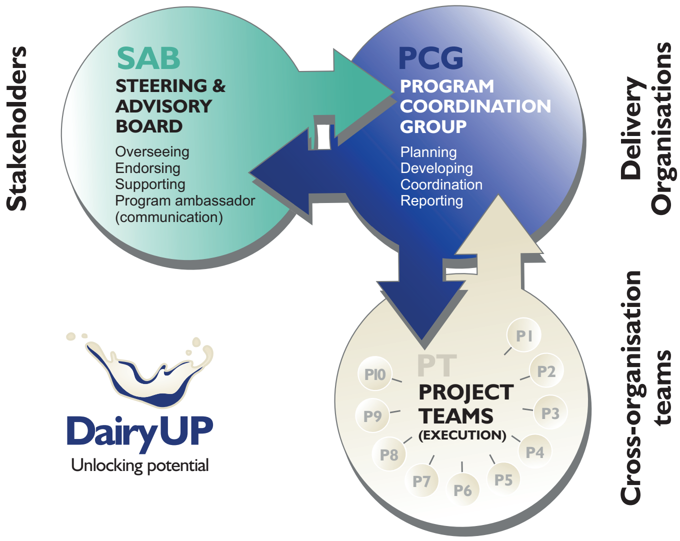
DairyUP is funded through the NSW Government's Bushfire Industry Package – Sector Development Grant (BIP-SDG) program, with cash and in-kind contributions from the Delivery, Partner and Additional Supporter organisations below.

The Program Coordination Group (PCG) has and executive role and the responsibility of delivering the program and managing the budget. The key delivery organisations are The University of Sydney's Dairy Research Foundation, Scibus, NSW DPIRD, and Dairy Australia.

The projects are delivered by individual Project Teams (PT), with the Steering & Advisory Board (SAB) overseeing the whole program and providing support to PCG and PT's.

Governance Model

Lead & Administering Organisation
Dairy Research Foundation (DRF)



Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Government Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | east AUSmilk Advocacy-Unity-Service | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Government Local Land Services | Norco

Additional program supporters, collaborations or partnerships

Charles Sturt University | DairyBio | DataGene | Eagle Direct | Entegra
Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

What is Dairy UP?

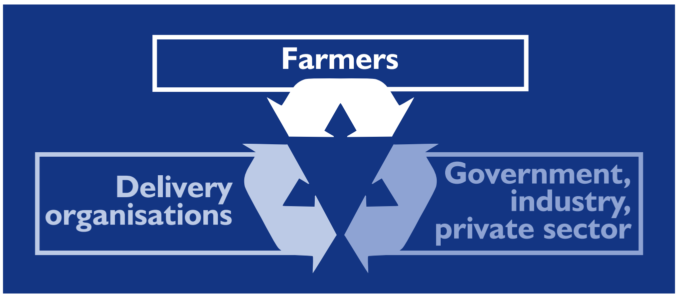
Dairy UP is a $16 million, five-year industry driven project with a portfolio of 10 research, development and adoption projects collectively aiming to realise three primary objectives:

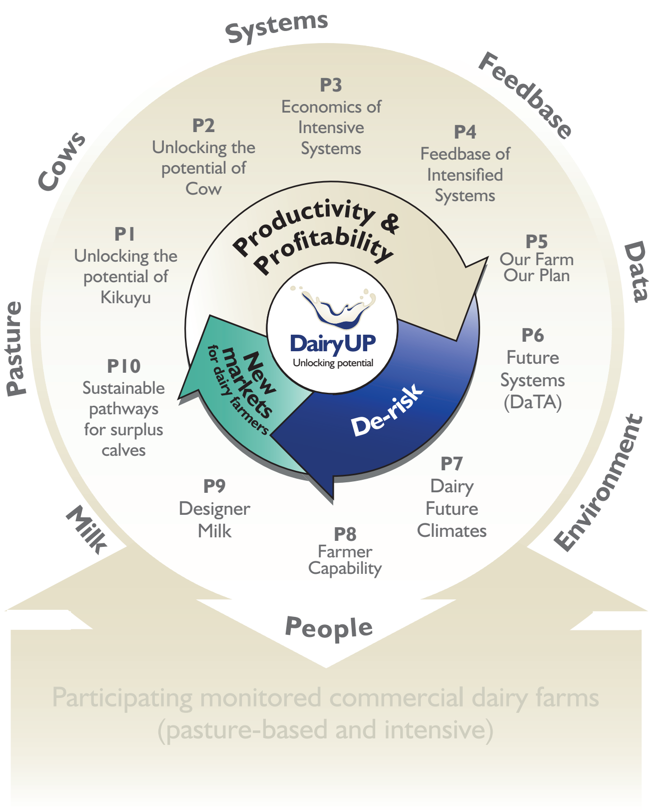
- Increase Productivity and Profitability by unlocking the potential of milk, the cow and water,
- De-risking the industry and
- Developing new markets.

A key part of Dairy UP is a coordinated network of partner farms across New South Wales (and beyond) providing valuable insights into real world application of new practices, including the challenges and benefits of new innovative technologies.

Dairy UP makes a big contribution to dairy research and development rejuvenation, attracting new researchers, PhD students and Industry investment.

The program has already attracted over $2.5M of additional income, including $1,098,280 in cash funding.





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SECTION ONE

Project Updates

Documents

Mid-project insights

P1a: Remote pasture monitoring

November 2024

Unlocking the potential of Kikuyu

Dairy UP's P1 project aims to unlock the potential of Kikuyu pastures used by NSW dairy farmers. P1 is a suite of five projects that collectively explore new management options to grow and utilise more Kikuyu over summer and increase the productivity of Kikuyu-based pastures.

P1a: Remote pasture management using advanced sensing technologies.

P1b: Antinutritional Factors (toxicity) P1c: Genetic Diversity of Kikuyu.

P1c: Genetic variability

P1d: Carbon on NSW Dairy Farms.

P1e: Nutritional Value.

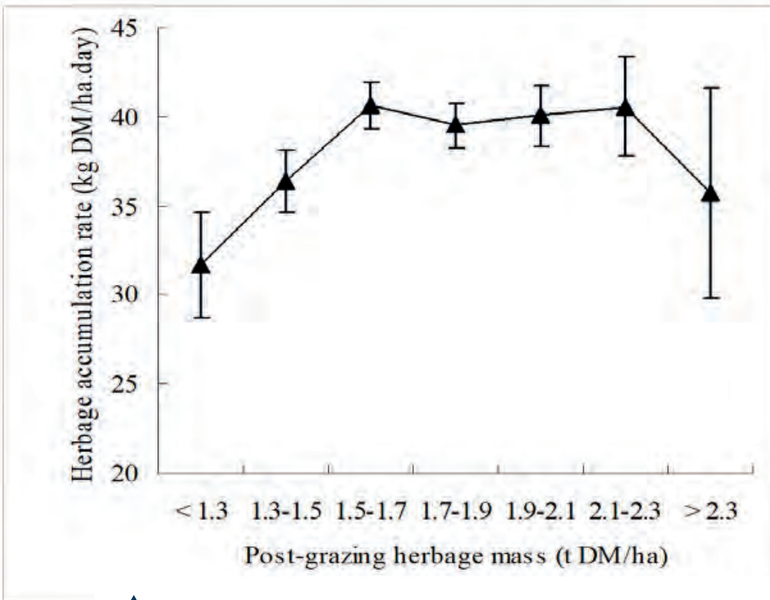
This document provides some insights based on mid-project results from P1a.

Residuals are not always ideal

Observations from monitoring 15 motivated farms in the Dairy UP project have found that despite the best intentions, there are times when the pasture on offer is too high (>2700 kg DM/ha), leaving greater than desired residuals (>1700 kg DM/ha). On the other hand, in the autumn slow growth is observed that often results in residuals far lower than 1700 kg DM/ha. Previous research shows a potential loss in regrowth rate of 25% for the following grazing where residual drops to <1,300 kg DM/ha. Several important things emerge from these observations.

Fluctuating growth rates

Growth rates change rapidly with seasonal conditions. This means at key times it can be hard to stay with a set rotation length and or stocking pressure – we need to recognise conditions that slow or speed growth rates and respond quickly.



▲ Impact of post grazing residual on regrowth

Targets and terminology

Targets are a useful tool and help refine what is ideal but different terms mean different things to different people, so the outcomes from using these targets are variable.

For example, the Pasture for Profit program is based on terms such as 3-leaf stage, 2700 kg DM/ha on offer and "canopy cover." But these terms actually mean different things to different people (and their advisors too). If six farmers or six agronomists had to visually estimate one paddock's residuals in terms of kg DM/ha we would probably get 12 very different answers.

Dairy UP's P1 project is focussing specifically on unlocking the potential of Kikuyu pastures for dairy farms. It's assessed a range of tools that improve pasture production and utilisation.

Satellite imagery

Dairy UP researchers are exploring the accuracy of satellite imagery on pasture biomass and therefore growth rates at any time.

There are many other research projects looking at similar objectives, but this allowed a good look at the coastal farming system of kikuyu and ryegrass. Fifteen farms at Bega, Tocal, Taree and Lismore were monitored using rising plate meters at five locations on each farm. The results were compared to satellite derived data from the Pasture IO platform.

It was not an easy task including some challenges that were expected. For example, as the regrowth of ryegrass or kikuyu reached "canopy cover" the satellite measurements of greenness and so growth – that is, NDVI – were less accurate because the reflection of light waves didn't change, but biomass continued to increase.

However, the number of satellites now in orbit has increased, providing greater accuracy and the ability to miss cloudy days. There's now a real opportunity to automatically measure and monitor pasture growth.

The results were encouraging but without adding the rising plate meter data, the variations were too high to confidently adjust supplements and grazing pressures at least in this region and given the conditions we faced.

However, the satellite results provide trends and could rank the relative amount of pasture in each paddock well. That is the data could provide insight into which paddock was next to graze but not necessary how much was really on offer.

This is not a closed case, as the technology continues to advance. Satellite data may provide more accuracy at lower biomass for example for monitoring residuals.

The data may also be able to provide more detail on pasture variability, such as how much pasture growth varies across a paddock and where is it consistently low or high. This aspect has yet to be fully explored but it is used widely in cropping.

Pasture accounting

Pasture monitoring platforms such as Pasture.io also offer some unexplored opportunities. For example, if a biomass measurement is accurate, it can automatically calculate pasture harvested per paddock over the year. It can monitor targets such as biomass pre- and post-grazing and rotation intervals.

This would help understand **the hidden cost** of less-than-ideal residuals. Already Pasture.io provides massive computing facilities for a dairy farm in that it measures growth on every paddock and calculates the feed wedge of the farm on any given day. It also calculates growth rates, leaf intervals and provides the platform to insert other weather data that could be useful.

All this data adds a level of complexity for an already complex industry: more electronic mediums when we are saturated with them, and it has had limited appeal to farmers who are pressed for time to manage farms.

There is opportunity for the platform and or Pasture.io to be used by consultants and other service providers to build their own service capabilities to reduce the load on farmers.

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Growing degree days

Field trials conducted by the Dairy UP team at the Corstorphine farm in Camden investigated the decline of Kikuyu quality with age. They found the quality of leaves declines with every day beyond the optimum grazing interval.

They used a simple technique called Growing Degree Days GDD to quantify this. The approach involves adding up the daily mean temperature above a minimum that the plants don't grow (usually 0°C for C3 plants like ryegrass and 10°C for C4 plants like kikuyu).

Being a daily measurement, it combines temperature and age effects on plant maturity and is also used to quantify measures of other things such as leaf stage interval and reproduction stimuluses.

There is an opportunity to automate the calculation of growing degree days within Pasture IO or other platforms. This could provide greater insight into the maturity of each rotation. The real power of this data is that it helps farmers anticipate the need to change course earlier and so make better decisions for rotation length. While this this is only fine tuning what we already do, it may prove very helpful.

Summary

Dairy UP research is moving pasture research forward but not without challenges. Satellite imagery is helpful but it needs more refinement and so more research. Dairy UP is working on many more pasture related projects, such as kikuyu varieties, kikuyu poisoning and carbon budgets for kikuyu pastures.

Read more

The hidden losses of pasture utilisation, Australian Farmer, December 2024, p 188-190

More info

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Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

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Project Update

P1a: Satellite Monitoring on NSW Dairy Farms

June 2023

Unlocking the potential of Kikuyu

Dairy UP's P1 project aims to unlock the potential of Kikuyu pastures used by NSW dairy farmers. P1 is a suite of five projects that collectively explore new management options to grow and utilise more Kikuyu over summer and increase the productivity of Kikuyu-based pastures.

P1a: Remote pasture management using advanced sensing technologies.

P1b: Antinutritional Factors (toxicity) P1c: Genetic Diversity of Kikuyu.

P1c: Genetic variability

P1d: Carbon on NSW Dairy Farms.

P1e: Nutritional Value.

This document provides an update on P1a: Remote Pasture Management.

Remote pasture management

This project is exploring new management options using advanced remote sensing technologies and monitoring systems for Kikuyu-based dairy systems in NSW.

The aim is to develop the tools for dairy farmers to make in-time grazing management decisions based on their farm's actual pasture cover and growth.

Dairy UP technical officers are working with dairy farmers in the north, mid and south coast NSW regions to adapt the Pasture.io monitoring system for Kikuyu based pastures for representative dairy conditions in NSW.

Pasture.io is a decision support tool that uses high resolution satellite images and local information (e.g. weather soil and farm management data) to help farmers monitor their pastures and make grazing management decisions. Utilising machine learning technologies, the software predicts pasture cover biomass and forecasts its production. It has been developed and validated for perennial ryegrass pastures and is used commercially in Australia and overseas.

Dairy UP's work aims to expand its application to Kikuyu pastures for NSW dairy farms.

Dairy UP monitor farms

The Dairy UP team is working with a network of 14 dairy farms across a variety of dairying regions to collect physical data including pasture cover, composition, quality and management.

For the first year, this involved a technical officer visiting each farm weekly to measure pasture cover with a rising plate meter and collect

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pasture samples for quality analysis. The results were compared with the predictions made by Pasture.io.

Year 1 progress update (June 2023)

Analysis of the first year's data has shown that satellite imagery alone is not accurate enough to make management decisions for Kikuyu pastures with confidence. Despite this, the decision support tool was seen by farmers as a smart platform to follow farm management and to coordinate activities with the staff.

Results so far indicate that satellite-imagery needs to be calibrated regularly (fortnightly) to provide accurate estimates of Kikuyu pasture cover and other measures to underpin grazing management decisions. This calibration involves incorporating fortnightly pasture cover measured with a rising plate meter from five representative paddocks on the farm.

As the software has the capacity for machine learning, this interval may be able to be extended in the longer term. However, for now, the Dairy UP team is investigating the effectiveness of fortnightly calibration on the actual grazing management decisions on the monitored farms.

We recognise that fortnightly monitoring of five paddocks with a rising plate meter is unlikely to be incorporated into the regular schedule by most dairy farms. However, if the practice proves effective, Dairy UP will investigate variations on the work flow, such as the fortnightly monitoring being performed by a service provider, or if a single farm can be monitored to calibrate Pasture.io for a number of neighbouring farms.

Next steps

From July 2023, Dairy UP technical officers will start visiting monitored farms fortnightly to measure five paddocks using a rising plate meter to calibrate satellite-driven predictions. For those farmers interested, the visits will be an opportunity to discuss pasture cover and growth, grazing management decisions and potential insights from the use of a management tool like Pasture.io.

The pasture data collected by Dairy UP can be used to calibrate satellite imagery from any other similar software.

More info

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Delivery organisations

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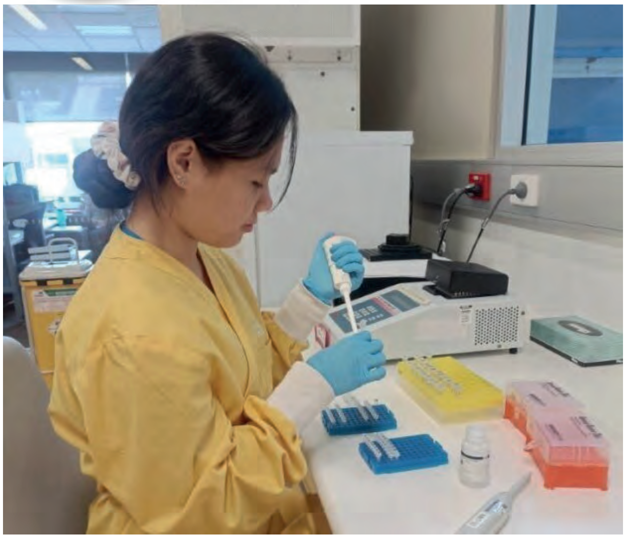
Project Update
P1b: Investigating Kikuyu Toxicity

March 2024



Kikuyu is a perennial pasture species commonly grown in NSW for livestock production.

It is classified as a C4 grass which means it is adapted to warm or hot conditions. Kikuyu is fast growing and produces more dry matter – of higher quality –than other C4 grass varieties.

However, there's still a lot to learn about Kikuyu, including uncovering the cause of Kikuyu poisoning – a risk for livestock producers.

Unlocking the potential of Kikuyu

Dairy UP's P1 project aims to unlock the potential of Kikuyu pastures used by NSW dairy farmers. P1 is a suite of five projects that collectively explore new management options to grow and utilise more Kikuyu over summer and increase the productivity of Kikuyu-based pastures.

P1a: Remote pasture management using advanced sensing technologies

P1b: Antinutritional Factors (toxicity)

P1c: Genetic Diversity of Kikuyu

P1d: Carbon on NSW dairy farms

P1e: Nutritional Value.

This document provides an update on P1b: Antinutritional Factors (toxicity).

Kikuyu poisoning

Cattle deaths and illness officially linked to Kikuyu poisoning are rare.

The last major event was in the NSW Hunter Valley in the early autumn of 2018-19.

This case was diagnosed because it included several farms reporting dead or dying animals within a few days of them grazing Kikuyu.

Kikuyu poisoning – or toxicity – is frequently associated with environmental conditions, specifically solely grazing, fast-growing Kikuyu in the autumn, immediately after a summer drought or prolonged dry conditions.

Cause

The compound or mechanism making Kikuyu toxic to cattle under these conditions is unknown.

Kikuyu toxicity is difficult to research because of the unpredictability and rarity of Kikuyu poisoning. The only definitive way to tell if cattle have Kikuyu poisoning is a combination of the history, clinical signs, and specially looking for damage to the forestomach (necropsy findings).

Specific signs linked to Kikuyu toxicity include dehydration, sham drinking (trying to drink but unable), abdominal pain, unsteadying gate, drooling and death. But not all cattle suffering from Kikuyu poisoning present with these signs. In some instances, the animals can recover, although they will not be as productive as before, given the damage to the digestive system.

Some affected cattle are reported as Kikuyu toxicity cases; however, many remain unreported, with their illness blamed on other causes or not investigated.

Project aim

DairyUP researchers want to find out why Kikuyu can become toxic, so dairy farmers can use the grass with confidence.

Ideally, project outcomes would include the development of new Kikuyu varieties that are less susceptible to toxicity events, diagnostic tests to evaluate pasture safety, in-field preventative treatments and treatments for affected cattle.

Alternatively, providing any sort of clarity around Kikuyu toxicity would also aid dairy farmers and their understanding of the issue as well as inform future grazing management practices and research.

Benefits

At the back of every livestock producer's mind – whose cattle grazes Kikuyu – is the looming threat of Kikuyu poisoning. Although Kikuyu poisoning is infrequent, it remains a risk and can prevent dairy farmers from unlocking all the benefits of Kikuyu.

Understanding the underlying reason for Kikuyu poisoning would enable dairy farmers to manage their herds and pastures with increased confidence. There would also be more assurance using Kikuyu as a feed option – potentially providing more homegrown feed alternatives year-round.

Kikuyu poisoning also affects beef cattle. Sheep and goats are also affected but are less susceptible. Therefore, any findings could benefit Australia's entire livestock sector.

Research approach

Collecting and analysing grass and soil samples across NSW has been a priority and is ongoing.

These samples are providing provide a normal "baseline" for reference and comparison with "toxic" Kikuyu.

These samples are being examined using a technology called metabolomics. Metabolomics gives a "fingerprint" of the many compounds included in a grass sample. Researchers will use this database of compounds to potentially identify toxic compounds.

In addition, the environmental conditions that are understood to precede Kikuyu toxicity have been created inside a greenhouse. This trial includes the most common commercial Kikuyu cultivar, Whittet, and developmental strains.

Researchers are examining how the different varieties and their associated microorganisms, including fungi, respond to the greenhouse conditions to identify what role genetics plays in Kikuyu toxicity or if potentially toxic microorganisms flourish under these conditions.

On-farm monitoring

Dairy UP researchers from the NSW Department of Primary Industries Elizabeth Macarthur Agricultural Institute and the University of Sydney visited the farms affected by Kikuyu poisoning in 2018-19, collecting soil and grass samples.

Researchers have also taken samples from other farms from across NSW and spoken to farmers about their observations of Kikuyu poisoning.

Progress update (March 2024)

Sample analysis and the greenhouse trial are ongoing.

Next steps

Sample analysis will continue as researchers build a database of Kikuyu metabolic compounds.

At the end of the greenhouse trial, microorganisms that flourished under the 'drought and rewater" cycle preceding Kikuyu

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toxicity will be examined.

Researchers will investigate if these microorganisms were linked to Kikuyu toxicity in the past and how this could affect cattle health.

The genetics of the Kikuyu varieties will also be studied to understand how they may or may not have better resilience to toxicity.

How farmers can help

The good thing about Kikuyu poisoning is that it's rare, but this means it can be difficult to source grass and soil samples from toxic pastures.

Researchers need as many "toxic" samples as possible for analysis.

Any farmer with suspected Kikuyu toxicity is encouraged to contact DairyUP researchers.

Collaborators

The P1b project is a collaboration between Dairy UP, University of Sydney and the NSW DPI.

More info

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Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

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Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Project Update

P1c Exploring Genetic Variability of Kikuyu

August 2025

Kikuyu cultivars

Kikuyu grass is a C4 grass adapted to both the tropics and temperate climates. It is fast growing and produces more dry matter of higher quality than most C4 grasses.

However, since the development of Whittet more than 50 years ago, only 2 new cultivars for grazing have been released (Acacia and Fulkerson).

Kikuyu genetic research

The University of Sydney in collaboration with Hatton's Turf Research has been breeding improved kikuyu grasses for more than 15-years. These new materials have greater biomass production, tolerance to salinity and drought and represent significant new diversity for nutritional factors.

Industry needs

Current kikuyu pasture cultivars are limited in adaptation, nutritional quality and scope.

However, the extent of adaptation in the new materials developed by the University of Sydney and Hatton's remains largely untested in most dairy producing areas. The nutritional status of these materials when grown in a broader range of environments is also untested. Such information could lead to the release of improved pastures and will provide a basis for continued breeding and selection.

Project aims

This project is exploring and evaluating promising lines of kikuyu that have been selected for increased biomass production and tolerance to salinity and drought.

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P1a: Remote pasture management using advanced sensing technologies

P1b: Antinutritional Factors (toxicity)

P1c: Genetic diversity of Kikuyu

P1c Genetic Diversity

P1d: Carbon on NSW dairy farms P1e: Real time prediction and manipulation of Kikuyu's nutritive value for animals.

P1e Nutritional value of Kikuyu

This document provides an update on P1c: Genetic diversity of Kikuyu.

Benefits

Given that Australia's pasture lands are increasingly subject to moisture stress and warmer temperatures, this climate-ready pasture could provide greater flexibility to the animal industries including dairy.

Findings to date

The Dairy UP team has identified three candidate lines of kikuyu with potential commercial valuable for dairy pastures.

Compared to the varieties currently used on NSW dairy farms (Whittet and Fulkerson), findings to date indicate that all three candidate lines show promise in terms of dry matter production, genetic diversity, disease resistance and nutritional value.

Research approach

Thirteen distinct kikuyu genotypes owned by Hatton's Turf Research Pty Ltd, were selected to be evaluated in small, replicated plots at the Plant Breeding Institute at Cobbitty during 2021/22. Two commercially available varieties (Whittet and Fulkerson) were included as controls.
The plots were exposed to natural conditions. Soil nutrient/moisture and daily weather were assessed throughout the experimental period. Plots were cut for biomass assessment at key periods of the year and rate and extent of re-growth assessed. Materials were screened for nutritive value and local adaptation. Concurrent pot studies were conducted in a hydroponic system for more detailed assessment of nutritive traits.

The same traits were assessed in the field at both locations for comparison and determination of stability.

Lines with potential

Based on the results, three new kikuyu lines were identified as candidates with potential commercial value. These were screened with larger plot trials in 2022/23.

Results from the initial plot trials indicated the three candidate lines were resistant to disease and grow quickly with high yields over 12 months (more than 14 tonnes/ha/yr). Their nutritional values were high in terms of crude protein, water soluble carbohydrates and fibre.

The 2022/23 plots were used to produce enough runners to establish field trials.

Field trials

The three candidate lines (and Whittet as a control) were further assessed in 2024/25 through replicated strip trials on three dairy farms in southern NSW (Bega, Berry, Corstorphine).

The trials ran from November to May with the strips managed as closely as possible to the farm's practices. Biomass was monitored using remote sensing technology and a rising plate meter. Grazing was allowed on one half of the trial and samples were collected for analysis from the mowed treatment. Biomass yield from mowing was used as a proxy for grazing and to compare with the grazing treatment.

Given the wet conditions during the 2024/25 trials, further field trials will be conducted over the 2025/26 summer to better understand the performance of the candidate lines under different seasonal conditions.

Disease resistance

Lines were assessed for disease resistance in glasshouse trials where plants were inoculated with either blackspot or kikuyu yellows.

All three of the candidate lines appear to be more resistant than Whittet to blackspot. One of the candidate lines appears to be more resistant to kikuyu yellows.

The 2025/26 field trials will be used for a field inoculation trial of black spot and kikuyu yellows.

DNA testing

Throughout all trials, samples have been collected for DNA testing. In addition, samples have been collected from regional dairy farms for testing.

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Results

The DNA analysis revealed more genetic diversity than expected with just 35% of sampled sites aligning with the Whittet and Fulkerson lines.

The three candidate lines are genetically distinct from the ones currently available commercially (largely Whittet, Fulkerson and Acacia).

Dry matter produced at on-farm trials varied between 8t/ha in the South Coast and 14t/ha at Camden, but the differences among the lines at each site were not statically significant. The unusually wet season meant there wasn't an opportunity to observe differences in ability to tolerate dry conditions and subsequent impact on yield.

The three candidate lines differ in disease resistance and chemical profile as follows.

- Line 2: the most disease resistant line with an intermediate chemical (nutritional) profile, similar to Whittet.
- Lines 8 &10: resistant to black spot but equivalent susceptibility to kikuyu yellows as Whittet and Fulkerson; well-balanced chemical (nutritional) profile.

There appears to be a relationship between kikuyu toxicity and kikuyu genotype, with more instances occurring at the sites where the Whittet and Fulkerson related materials were grown. Further investigation is needed to make a definitive conclusion.

Next steps

Further field trials will be conducted over the 2025/26 summer to better understand the performance of the candidate lines under different seasonal conditions. In field inoculation of black spot and kikuyu yellows will be conducted to further investigate disease resistance.

Path to market

Collaboration with a commercial partner provides a clear path to market.

Once superior lines have been identified Hatton's Turf will undertake multiplication, dissemination and marketing.

PhD student

Several lines are concurrently being testing in P1b for differential toxicity response and a PhD student, Vivien Tan, is working across both P1b and P1c to document outcomes.

Collaborators

The P1c project is a collaboration between researchers from Dairy UP, University of Sydney and Hatton's Turf.

More info

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Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

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Project Update
P1d: Carbon on NSW Dairy Farms

December 2023

What's driving the carbon balance?

Understanding the environmental impact of dairy farming is essential to develop ways to reduce greenhouse gas emissions and a path to carbon neutrality.

Some elements about emissions on dairy farms, are well understood, for example some sources and sinks, some mitigation strategies, and the carbon balance of some production systems.

But the path to carbon neutrality – including other sources of emissions and other carbon sinks – aren't understood in detail, nor has information been tested in all types of farming systems with a range of management practices.

That's why this Dairy UP project, with support from the NSW Environmental Protection Authority (EPA), is investigating the sources of dairy production greenhouse gas emissions, how to mitigate and accurately measure some of these emissions and move towards carbon neutrality.

This research will fill industry knowledge gaps with local studies applicable for the NSW dairy industry. This project initially focussed on Kikuyu pastures but additional funding from EPA enabled it to be expanded to also include intensive dairy production systems.

A path to carbon-neutral dairy

The Dairy UP team is working with the NSW Environmental Protection Authority (EPA) to identify and evaluate options for carbon neutral dairy production.

This work comes under the Dairy UP program called "Unlocking the potential of Kikuyu-based systems" and is one of five projects.

This project, known as P1d, focuses on the environmental impact, especially carbon.

Other programs include:

P1a: Remote pasture management

P1b: Anti-nutritional factors (toxicity)

P1c: Genetic variability

P1d: Carbon on NSW dairy farms

P1e: Modelling/quality

For more information visit www.dairyup.com.au

Why carbon research?

The Australian dairy industry is facing mounting pressure from many stakeholders to reduce its greenhouse gas emissions.

Customers want dairy to reduce its impact on the environment, while the Australian Government has committed the nation to net zero emissions through The Paris Agreement, an international treaty on climate change.

In line with these market, consumer and regulatory expectations, Dairy Australia has pledged to reduce the emissions intensity of the Australian dairy industry to 30 per cent less than 2015 levels by 2030.

To reduce emissions, the industry needs to accurately understand its existing emissions and how different management practices and farming systems affect output and carbon sequestration (capture and storage).

Potential benefits

This Dairy UP project will help the NSW Dairy industry to meet the industry's emissions reduction targets.

It will also fill knowledge gaps within the industry to enable dairy farmers to estimate their farm's emissions with increased accuracy, while providing practical ways to decrease emissions.

This project is using the Australian Dairy Carbon Calculator and the Dairy Greenhouse Gas Accounting Framework which means the work could also be used by the wider industry, beyond NSW.

There's also potential for this research to assist other Australian livestock industries.

The data collection method is aligned with the Australian Government requirements for carbon trading which means participating farms will be able to use the soil information if they want to embark on soil organic carbon sequestration (capture and storage).

Multipronged approach

This Dairy UP project includes many areas of research to gauge the best understanding of carbon on NSW dairy farms.

Information collected will be combined and used to model the greenhouse gas balance for commercial intensive and pasture-based dairy farms in NSW.

The research includes a literature review, analysis of pasture and the carbon cycle, measurements of soil organic carbon on NSW dairy farms and examination of the impact of cattle nutrition and productivity on emissions.

Literature review

This work examined research and studies from across the globe to understand what's been achieved.

Progress (December 2023)

The literature review has been completed. It established a baseline situation and modelling for carbon neutral scenarios.

The review highlighted the need for data on soil carbon stocks and sequestration, cycling of greenhouse gases from the land, impacts of nutrition under Australian conditions, and inclusion of intensive dairy systems.

Pasture and the carbon cycle

Using eight chambers and a greenhouse gas analyser on pastures, researchers are measuring the fluxes – the kilograms of greenhouse gas emitted or taken up per hectare per day – from different pasture types and management practices.

This work included a calculation of the carbon dioxide equivalent of different pastures.

These measurements will be used to better understand the carbon cycle and enable more accurate measurements.

Progress (December 2023)

Early results indicate that every hectare of pasture, on average, was capturing about 8kg of carbon dioxide equivalent per day with a minimum pasture uptake of -765 and a maximum emission of 445 CO_2e kg/ha/day.

Researchers are now testing the idea that of carbon dioxide emitted from each cow each day –

11 kg CO_2e cow/day – potentially 8kg CO_2/ha/day comes CO_2 taken from the pastures.

This information will be fed into greenhouse gas calculators to help calculate an accurate greenhouse gas balance for farms.

Soil organic carbon measurements

Up to 120 soil samples per farm from 10 participant farms are being analysed for soil organic carbon. This data will tell dairy farmers and researchers about the "carbon capital" stored in the soil. This measurement will establish a greenhouse gas emission baseline and provide insight into how different pastures, crops, and management practices affect soil carbon.

Progress (December 2023)

Soil tests from two farms have been analysed.

Initial findings from the University of Sydney Camden farm showed native pasture has the highest soil organic carbon at 4.8 per cent. This was contrary to the findings from the soil and landscape grid of Australia maps – used for initial reference – which estimated the native pastures would have the lowest soil organic carbon.

The lowest soil organic carbon area at the Camden property, according to the analysis, was the cropping paddocks at 1.2 per cent with Ryegrass and Kikuyu pastures at about 3 per cent.

Cattle nutrition and productivity

The diets of dairy cattle, including diet composition, concentrate feeding rates and pasture quality, are being examined to better understand how this affects emissions.

Progress (December 2023)

NSW Dairy Farm Monitor Project data was used for the first part of this project to examine the effect of concentrate feeding on productivity, greenhouse gas emissions and economics.

This analysis found that farms with the highest Earnings Before Interest and Tax (EBIT) fed the lowest concentrate (1 tonne or less per cow per year). But they had the greatest CO_2 emissions intensity per kg of fat and protein corrected milk including emissions from concentrate fed.

Farms with the next highest EBIT fed 2-3 tonnes of concentrate/cow/year and had the lowest emissions intensity. However, this study did not yet consider soil carbon and pasture cycling of greenhouse gases amongst others.

More research questions

The research has generated lots of questions and new considerations when it comes to calculating the greenhouse gas balance on dairy farms.

For example, researchers want to further explore if there are options to gain carbon credits for a farm through feeding, pasture management and soil organic carbon.

There are also questions now about management practices and how variations could be accounted for in an overall farm emissions calculator.

And when it comes to soil organic carbon, researchers want to learn more about converting cropping areas to permanent pastures, the time it would take, and the effect of conversion on carbon sequestration.

Next steps

On-farm measurement of soil organic carbon will continue until all 10 farms have been analysed. Data collection of sources and sinks from these farms will then allow the calculation of a more holistic greenhouse gas balance.

Researchers will also further investigate pasture management practices and productivity to determine the effect this has on the carbon cycle.

Additional research will look at the effect of different ingredients in a cow's diet and the role these ingredients play in emissions.

PhD student

Mulisa Faji, University of Sydney

Collaborators

The scope of this Dairy UP project has been expanded thanks to additional funding from the NSW Environmental Protection Authority (EPA).

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Journal article

Dida M. F., et al (2024), Dietary Concentrate Supplementation Increases Milk Production and Reduces Predicted Greenhouse Gas Emissions Intensity in Pasture-based Commercial Dairy Farms. Journal of Dairy Science March 22, 2024

More info

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Carbon terminology

Carbon calculator: a tool for farmers to measure their farm's carbon footprint and understand the sources of emissions and explore options for reducing emissions.

Carbon credit (carbon offset): permits the owner to emit a certain amount of carbon dioxide or other greenhouse gases.

Carbon dioxide equivalents: a measure used to compare emissions from various greenhouse gasses on the basis of their global warming potential by converting amounts of other gasses to the equivalent amount of carbon dioxide with the same global warming potential.

Carbon sequestration: the process of capturing and storing carbon dioxide from the atmosphere.

Fat and protein corrected milk emissions intensity: kilograms of carbon dioxide equivalents per kilogram of fat and protein corrected milk.

Fluxes: the kilograms of greenhouse gas emissions or uptake per hectare per day.

Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

Additional program supporters, collaborations or partnerships

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Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Project Update

P1e: Kikuyu nutritional value

July 2024

In Australia's grazing-based dairy systems, pasture utilisation is closely linked to profitability. Kikuyu is well-adapted to subtropical areas. It is fast growing but of moderate quality and generally perceived as a grass of poor nutritive value for dairy cattle. The Dairy UP team is working to change that.

The timing of grazing has a big impact on Kikuyu's nutritive value which affects pasture utilisation and profitability.

Kikuyu leaves lose quality very rapidly if not consumed at the right time, and the window of opportunity is generally smaller than for temperate grasses.

Grazing intervals also affect stem content. This matters because the nutritive value is affected by the proportion of the pasture that is made up of stems, leaves etc. Stems are more fibrous so the digestibility and nutritive value of kikuyu pasture is reduced if there's higher stem content.

Dairy UP research

This project aims to better understand and predict the rapid, short term daily changes in the nutritive quality of Kikuyu. This will enable the development of pasture management strategies to better manage the quality of Kikuyu pasture regrowth and prevent milk production losses due to the decline in nutritive value.

Unlocking the potential of Kikuyu

Dairy UP's P1 project aims to unlock the potential of Kikuyu pastures used by NSW dairy farmers. P1 is a suite of five projects that collectively explore new management options to grow and utilise more Kikuyu over summer and increase the productivity of Kikuyu-based pastures.

P1a: Remote pasture management using advanced sensing technologies

P1b: Antinutritional Factors (toxicity)

P1c: Genetic Variability

P1d: Carbon on NSW Dairy Farms

P1e: Kikuyu's Nutritive Value for Animals

This document provides an update on P1e.

Research approach

The Dairy UP team is modelling changes in the nutritive value of Kikuyu plants at different stages of regrowth. They are adapting a model originally developed for tall fescue and ryegrass.

Plot-scale, field experiments have been conducted in 2023 and 2024 to provide data to calibrate the model for Kikuyu.

Model

The model can simulate changes in leaf digestibility during regrowth at different leaf stages. It accounts for leaf growth, leaf age, leaf size and nutritive value (fibre content, fibre digestibility and metabolizable energy).

Field experiments

The first stage involved controlled field studies with small, replicated plots of Kikuyu under different growing conditions.

This enabled detailed assessment of plant morphology (structure) and nutritive value traits including age and leaf length, leaf number per tiller, fibre (NDF, ADF) and digestibility (DMD and NDFD). This data is being used to quantify, model and predict the main factors affecting the fast decline in Kikuyu nutritive value during regrowth.

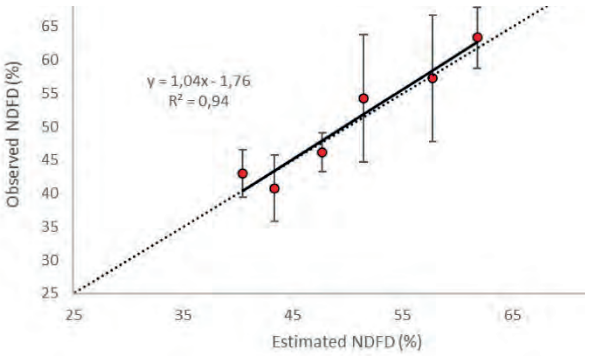
Progress update (July 2024)

Field experiments

Three (2022, 2023 and 2024) field experiments were conducted. The first two were used for model development and parametrisation. The last one was used to validate the model (compare the model predictions with the observed, independent, values/data).

Model

The model has been calibrated using data from the field trials. The quality sub-model has been validated and is very accurate (see graph). The model shows good accuracy of predicting the decline in digestibility associated with leaf stage.



Further work is underway to refine the sub-model for morphology (plant structure).

Factors affecting nutritive value

The main factors affecting nutritive value have been identified. Early results are consistent with previous studies, showing that the main factors affecting the nutritive value of Kikuyu are: leaf length, leaf age, senescence (leaf aging/decay).

Next steps

Future work is exploring the relationships between nutritive value data and yield to link changes in nutritive value (quality) with NDVI (satellite imagery), hopefully improving the efficacy of remote monitoring tools for farmers.

Related projects

Project P1e is using data from the Dairy UP's Remote Farm Monitoring Network (P1a) and from P1c: Exploring the genetic variability of Kikuyu.

The modelling work is based on earlier work that modelled changes in pasture fibre digestibility (Insua et al., 2019a) and integrated those changes with remote sensor-derived data of pasture biomass and growth (Insua et al 2019b).

Collaborators

The P2e project is a collaboration between the University of Sydney and the UIB, Argentina.

Read more

Insua J. R., Agnusdel M. G., Berone G. D., Basso B. and Machado C. F. (2019a) Modeling the nutritive value of defoliated tall fescue pastures based on leaf morphogenesis. Agronomy Journal, 111, 714-724.

Insua J. R., Utsumi S. and Basso B. (2019b) Assessing and modeling pasture growth under different nitrogen fertilizer and defoliation rates in Argentina and the United States. Agronomy Journal, 111, 702-713.

More info

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Project Update

P2a: Metabolic investigations into dairy cow longevity

September 2025

Longevity matters

Cows tend to produce more milk with each lactation: older cows produce about 16% more milk than their younger counterparts.

But cows in Australian dairy herds are young. Only 10% of cows produce milk for five lactations or more and about 60% of the average national milking herd has calved twice or less.

Optimising the productive life of dairy cows ensures dairy farm businesses receive the best return on their investment from rearing the calf; it also increases milk production and reduces the environmental footprint of individual cows.

David Sheedy's PhD investigated metabolic markers that could be associated with longevity in dairy cows.

Benefits

Retaining the best dairy cows in herds for longer is expected to make dairy businesses more profitable and less risky.

Thanks to technology such as sexed semen and fixed time artificial insemination, retaining more older cows could also provide the opportunity for a dairy business to produce more dairy-beef.

Increasing the proportion of older cows in a dairy herd would also ensure that dairy farm businesses receive a return on the investment in rearing these calves. A full return for the cost of rearing a dairy heifer often isn't realised until she calves for a third time.

Unlocking the potential of cows

Dairy UP's P2 project aims to unlock the potential of dairy cows to achieve their genetic potential under NSW conditions.

P2 is a suite of seven projects that collectively explore ways to profitably increase both productivity and wellbeing in commercial settings.

P2a: Cattle Longevity: Age and Parity & Intensive Herds
P2a: Longevity: Future
P2b: Early Alerts
P2c: Milk as a Diagnostic Tool
P2d: Facility Design for Cow Comfort
P2e: Calf Husbandry
P2f: Infectious Diseases ('Infectome')
P2g: Heifers Early Calving

This document provides a summary of the findings from research undertaken by David Sheedy for his PhD thesis which contributed to Project P2a.

From an industry and farm perspective, reducing the "wastage" of older cows is good news for dairy's environmental footprint. The more milk a cow produces over its lifetime, the less its environmental emissions intensity.

In addition, there's expected industry "social license" benefits from optimising the longevity of dairy cows.

Research approach

This project established a unique large-scale data set, created by a partnership between DataGene and Scibus. It includes herd test data and farm management records from selected Australian dairy herds with excellent quality records. Weather, bulk milk tank and pasture data are also included.

There are currently 29 Australian dairy herds providing farm records for inclusion in the data set. Fourteen of these herds are pasture-based and 15 operate contained housing systems.

The project also involved metabolomics in collaboration with researchers at Agribio, Victoria. Metabolomics is the large-scale study of small molecules called metabolites within each cow and can provide insights into health and longevity.

Blood samples were taken from about 1700 cows (half at peak milk production and half dry) for metabolomic analysis

Novel statistical methods were used to gain insights into relationships between blood fats and cow age/parity, feeding system and longevity.

Key findings

1. Health and parity
The results confirmed findings from earlier studies that used previous health and reproduction data from 13 studies conducted in Australia, Canada, and the USA.

As cows age (especially beyond the second lactation):

- Pregnancy risk decreases (they are harder to get in calf)
- Mastitis risk increases.
- Lameness risk increases.
- Survival (culling or mortality) risk increases.

2. Body condition and body weight
As cows age, they gain weight but lose body condition. This occurs in both pasture-based and contained housing systems. The exception was cows entering their second lactation, who often had the lowest body condition and low body weight.

Albumin, a blood protein, was strongly associated with high body condition and body weight.

This finding paves the way to develop nutritional interventions (protein metabolism) to improve body condition in older cows.

3. Blood lipids (fats) and age
This work investigated 185 blood lipids in cows of different ages.

The results showed that older dairy cows had lower levels of omega 3 fatty acids in their blood.

This is an important finding as omega 3 fatty acids have been associated with improved reproduction, health and possibly survival in cattle.

4. Blood lipids (fats) and survival/longevity
To investigate survival, cows that had blood samples taken were followed for about 600 days and all exit reasons were recorded.

Multiple lipids were associated with the timing of cow removal. Importantly, this included the omega-3 fatty acids that were associated with increased survival time.

5. System differences – lipids and health
Herds in contained housing had higher levels of mastitis compared to pasture-based herds. However, there was no difference in reproductive performance or lameness. Increasing parity had a larger impact on these metrics than the effect of housing system.

Cows in contained housing systems had lower blood levels of omega 3 fatty acids and higher omega 6 compared with pasture-based cows of the same age.

The difference in omega fatty acid profiles are likely to be associated with maize silage which is the main forage source in contained housing TMR diets. Maize silage is comparatively low in omega 3 fatty acids and high in omega 6, while fresh pasture has high omega 3 and low omega 6 content. A different lipid profile between housing systems may imply different survival risks between systems.

Implications for future

Collectively, the findings from this work and earlier studies suggest that targeting the fat profile of diets could help optimise longevity in Australian dairy herds. Specifically, supplementary omega-3 warrants further investigation.

Collaborators

The data base used for this work was developed through a collaboration between researchers from Dairy UP, Scibus, DataGene, AgriBio and the participating commercial farms.

Read more

Lean, I.J. et al. (2022) Associations of parity with health disorders and blood metabolite concentrations in Holstein cows in different production systems. J Dairy Sci. 2023 Jan;106(1):500-518.

Lean, I.J. et al. (2022) Increased parity is negatively associated with survival and reproduction in different production systems. J. Dairy Sci. 106:476–499

Lean, I.J. et al. (2022) Holstein dairy cows lose body condition score and gain body weight with increasing parity in both pasture-based and total mixed ration herds. JDS Communications, Volume 3, Issue 6, 431 - 435

Sheedy, David B. et al. (2025) Associations among body condition score, body weight, and serum biochemistry in dairy cows. Journal of Dairy Science, Volume 108, Issue 4, 4131 - 4148

Sheedy, David B. et al. (2025) A large multisite lipidomic investigation of parity and aging in dairy cows. Journal of Dairy Science, Volume 108, Issue 3, 2897 - 2913

Sheedy, David B. et al. (2025), Confinement and pasture-based dairy herds differ in plasma lipid profiles, Journal of Dairy Science, in press

More info

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Project Update
P2b: Early Alerts

August 2024

This project aims to create an early-warning system about disease outbreaks for farmers, vets and other people working with livestock.

Providing early alerts for the dairy industry about livestock diseases is important to ensure necessary protective actions are in place as soon as possible or the appropriate investigations can begin promptly.

The project is investigating two different alarm systems. The first is for immediate and confirmed threats such as army worms, foreign animal diseases and three-day sickness (BEF).

The second is designed to understand if a collection of signs or symptoms displayed might indicate sickness.

Benefits

Detecting diseases early and providing timely information to relevant people could help reduce the severity of the illness and potentially limit any potential spread.

Early detection could also ensure that relevant investigations into the disease could begin as soon as possible, collecting and analysing timely data, tests, and other relevant information.

Unlocking the potential of cows

Dairy UP's P2 project aims to unlock the potential of dairy cows to achieve their genetic potential under NSW conditions.

P2 is a suite of seven projects that collectively explore ways to profitably increase both productivity and wellbeing in commercial settings.

P2a: Cattle Longevity: Age and Parity & Intensive Herds

P2a: Longevity: Future

P2b: Early Alerts

P2c: Milk as a Diagnostic Tool

P2d: Facility Design for Cow Comfort

P2e: Calf Husbandry

P2f: Infectious Diseases ('Infectome')

P2g: Heifers Early Calving

This document provides an update on P2b: Early Alerts.

Alerts informing dairy farmers, veterinarians and other industry stakeholders working with livestock could also uncover diseases earlier and facilitate the detection of additional cases.

As well as providing a biosecurity tool, this project will benefit the health and welfare of animals, through earlier detection and appropriate intervention.

While this research is part of a NSW project, it could have relevance nationally.

Research approach

This project is underpinned by syndromic surveillance.

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Syndromic surveillance draws on a wide range of data sources looking for signs that might indicate sickness – otherwise known as a change in disease level.

Data sources that could be used in this project include:

- Herd recording information
- DataGene's central data repository
- Diagnostic laboratory information (government and private labs)
- Records from selected Dairy UP monitoring farms
- Farm advisor records
- Abattoir records
- The national arbovirus monitoring program.

The first step is to analyse the data to understand what is 'normal' so that statistically relevant changes can be identified. For example, it's normal for abortions to occasionally occur on dairy farms. The Dairy UP team wants to determine the threshold of the number and/or frequency of abortions that should trigger an alarm for investigation and action. This information is being obtained in P1a:

The project is also investigating the best way to centralise the information – for example using a web portal or interface system. The final step is to determine how to deliver the alerts effectively and efficiently.

Progress update (July 2024)

The project has been delayed by developmental delays with software and the scope has been limited to ephemeral fever, fall army worm and facial eczema.

Next steps

The next steps are to align the method of alerting farms with sufficient time to enact changes.

Related work

This project is linked with the following Dairy UP projects:

P1a: Cattle Longevity
P2c: Milk as a Diagnostic Tool,
P9b: Milk as an indicator of Heat Load
P2e: Calf Husbandry
P2f: Infectious Diseases.

Collaborators

The P2b project is a collaboration between Scibus, NSW DPI.

More info

Project lead
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Scibus
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Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

Additional program supporters, collaborations or partnerships

Charles Sturt University | DairyBio | DataGene | Eagle Direct | Entegra
Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

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Project Update
P2c: Milk as a Diagnostic Tool

October 2023

Milk as a monitoring tool

This project aims to investigate opportunities to use milk samples as a monitoring and diagnostic tool in Australian dairy herds.

Milk samples have the potential to be used to monitor, predict and manage risks to dairy cow health, productivity and fertility. For examples, milk samples can provide insights about dietary imbalance, bacterial and viral diseases and parasitic infection.

These insights can be at a herd level (from bulk tank milk samples) or individual level (from herd test samples).

Why bother?

As a result of this work, the NSW dairy industry could use bulk tank milk as a cost-effective and fast way to automate and monitor herd health changes, potentially equipping veterinary services, or milk processors with new tools to assist farms as part of an efficient integrated farm service. While the work is NSW-focussed, the outcomes are potentially applicable to all Australian dairy herds.

Unlocking the potential of cows

Dairy UP's P2 project aims to unlock the potential of dairy cows to achieve their genetic potential under NSW conditions.

P2 is a suite of seven projects that collectively explore ways to profitably increase both productivity and wellbeing in commercial settings.

P2a: Cattle Longevity: Age and Parity & Intensive Herds*

P2a: Longevity: Future*

P2b: Early alerts*

P2c: Milk as a diagnostic tool*

P2d: Heat stress*

P2e: Calf husbandry*

p2f: Infectious diseases ('Infectome')

This document provides an update on P2c: Milk as a diagnostic tool. This project is closely linked with P2f: Infectious diseases.

Benefits

Using milk as a monitoring and diagnostic tool has potential benefits at the industry, herd and individual cow level.

Ultimately, the diagnostic capability of bulk tank milk could reduce the risk of disease spread within and among herds.

At an industry level this is vital for biosecurity as the detection of pathogens or specific antibodies in milk can be used for monitoring endemic diseases within a farm, region, or country.

For example, antibody testing for Mycoplasma bovis (which causes pneumonia, mastitis and arthritis in cattle) can be conducted at bulk tank milk level.

Using bulk tank milk as a diagnostic tool on farm would help farmers make informed business management decisions to improve animal well-being, productivity, and profit.

For example, early and accurate detection of metabolic disorders can guide intervention strategies, while bulk tank milk urea and protein content are useful indicators of herd nutrition.

Bulk tank milk could also become a cost-effective and efficient assessment of a herd's disease status with this information supporting disease control programs for viral diseases.

At an individual level, the early diagnosis and treatment of infections and nutritional disorders improves animal health and welfare.

Progress update (Oct 2023)

The first stage of this project was a literature review, which was completed in 2023. The Dairy UP team explored and evaluated previous work, from a variety of authors, focusing on the role of milk as an indicator for health, production, and reproduction risks.

The findings from this review were summarised in a series of articles published in the Australian Veterinary Journal as invited reviews. The papers focused on milk as an indicator of dietary imbalance, milk as a diagnostic fluid for udder health management and milk as a diagnostic fluid to monitor viral diseases in dairy cattle.

This review also informed further consideration of the development of diagnostic tests using milk, in addition to those already commercially available.

Technology opportunities

Testing bulk tank milk is a fast and cost-effective way to monitor the health of Australian dairy cows.

But testing "pooled" milk does come with challenges.

For example, the accuracy of tests relies on achieving both low false positive and low false negative estimates together. This can be difficult and influences the value of the tests to industry.

Researchers concluded that the integration of new biotechnologies could enhance multiplexing and data interpretation for comprehensive surveillance.

In addition, new technologies such as matrix-assisted laser desorption/ionization time of flight (MALDI-TOF) or loop mediated isothermal amplification (LAMP) would offer new insights into intramammary infection, in the fight against mastitis, but aren't used with bulk tank milk yet.

Next steps

Priorities for the coming year include creating a path to on-farm and industry implementation.

The second stage will involve working with industry and government stakeholders such as the New South Wales Department of Primary Industries (DPI), herd recording business Dairy Express and milk manufacturers.

It's expected these groups will meet as part of a "round table" to develop a way to use bulk tank milk and herd testing samples for additional monitoring.

Stage three of the project will investigate the potential for external funding to conduct longitudinal monitoring – a research design involving repeated observations – of infectious diseases and implement tests for bulk tank milk at the NSW DPI Elizabeth Macarthur Agricultural Institute.

Collaborators

The P2c project is a collaboration between researchers from Dairy UP, University of Sydney, NSW DPI and Scibus.

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More info

AVA Journal articles

Milk as an indicator of dietary imbalance
Milk as a diagnostic fluid to monitor viral diseases in dairy cattle
Milk as diagnostic fluid for udder health management

Project lead
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Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

Additional program supporters, collaborations or partnerships

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Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Project Update

P2d: Facility Design for Cow Comfort

November 2023

Heat stress in Australian dairy cattle

Heat stress is a profound issue in the New South Wales and the broader Australian dairy industry. Cows in hot, humid conditions eat less, resulting in reduced milk production and loss of bodyweight, potentially leading to health and reproductive challenges.

Australian dairy farmers use a range of strategies to manage their herds in hot, humid weather. These include fans, sprinklers and management adjustments to diet, mating and daily routine.

Dairy UP heat stress research

This project aims to uncover the most effective ways to prevent or minimise the effects of hot, humid weather on dairy cows.

It builds on existing heat stress knowledge, with information collected from an extended period of cow and herd monitoring.

Both pasture-based and intensive-housed cow dairy farms are included in this project which will also investigate the interaction between heat stress and a cow's diet.

The project has the potential to "break whole new ground" as the first Australian research into heat stress and its links with diet in dairy cattle.

Unlocking the potential of cows

Dairy UP's P2 project aims to unlock the potential of dairy cows to achieve their genetic potential under NSW conditions.

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P2a: Cattle Longevity: Age and Parity & Intensive Herds

P2a: Longevity: Future

P2b: Early Alerts

P2c: Milk as a Diagnostic Tool

P2d: Facility Design for Cow Comfort

P2e: Calf Husbandry

P2f: Infectious Diseases ('Infectome')

P2g: Heifers Early Calving

This document provides an update on P2d: Facility Design for Cow Comfort.

Benefits

The findings will provide a clearer understanding of the acute and long-term "lag" effects of heat stress on dairy cattle.

This information will also better equip farmers to manage and plan for heat stress events, including the days following.

Better heat stress management will also improve dairy cow health, reproduction, production, and welfare. This will make a positive contribution to the profitability of NSW dairy businesses and reinforce NSW dairy farmers' social license to operate.

In addition, identifying the heat mitigation strategies which are best suited to specific dairy systems will support the development and improvement of management approaches and facility design.

On farm monitoring

This project is monitoring 15 intensive and 15 pasture-based dairy herds to measure the effects of heat mitigation strategies across an extended period to determine the best on-farm strategies to reduce heat stress within dairy herds.

Research approach

Different heat stress mitigation methods are used in all 30 herds and the cows' reaction are being recorded at various points in time.

This information will provide health, welfare, and production data from cows during a heat event and for the days after.

Time series analysis
This work relies heavily on time-series analysis on-farm to understand the causes, trends, and patterns of heat stress in dairy cows.

Time-series analysis for heat stress involves the collection of data at consecutive points in time to paint an accurate picture of the effect of a heat event.

Time-series information will enable researchers to pinpoint what happens and when to dairy cows. For example, researchers anticipate learning more about the effect of heat stress on fertility as any potential issues generally arise four days after a heat event.

Big data
Cow and herd information is also being added to data we collect on farm and climate data collected from nearby weather stations.

Previously published information from the USA is being used as a starting point to understand the link between heat stress and a cow's diet.

Progress update (October 23)

All 30 dairy herds have been enrolled in the heat stress research project.

Recording for information from onsite or nearby weather stations has started and observations of the cattle have also begun.

Next steps

Priorities for the coming year include monitoring the 30 herds and nearby weather stations, obtaining feed samples, collecting data and comparing the heat mitigation strategies.

Collaborators

The P2d project is a collaboration between Dairy UP, Scibus, Charles Sturt University, Leslie Manor Trust and Eagle Direct.

This project is closely linked with the following Dairy UP projects:

- P6a optimising on-farm energy use and cooling systems
- P6b Identifying and breeding dairy cattle with resilience to environmental extremes (drought)
- P9 Designer Milk.

Read more

Rossow HA, Golder HM, Lean IJ. Variation in milk production, fat, protein, and lactose responses to exogenous feed enzymes in dairy cows. Applied Animal Science. 2020 Jun 1;36(3):292-307

More info

Project lead

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Project Update

P2e: Calf husbandry

August 2024

The early life performance of a calves on dairy farms is strongly associated with lifetime productivity in the herd. Calves reared on dairy farms may include both female calves for replacements and non-replacement calves reared for dairy beef or other markets.

Improving calf care reduces antimicrobial use, lowers mortality rate, improves dairy business profitability and helps maintain social licence.

There are two elements to the project:

- Automated calf rearing.
- Rearing Holstein steers for dairy beef.

Unlocking the potential of cows

Dairy UP's P2 project aims to unlock the potential of dairy cows to achieve their genetic potential under NSW conditions.

P2 is a suite of seven projects that collectively explore ways to profitably increase both productivity and wellbeing in commercial settings.

P2a: Cattle Longevity: Age and Parity & Intensive Herds

P2a: Longevity: Future

P2b: Early Alerts

P2c: Milk as a Diagnostic Tool

P2d: Facility Design for Cow Comfort

P2e: Calf Husbandry

P2f: Infectious Diseases ('Infectome')

P2g: Heifers Early Calving

This document provides an update on P2e: Calf Husbandry.

Automated calf rearing

The project was undertaken as part of Dr Sarah Legge's PhD thesis, titled '*The lasting impact of calf performance*'.

The study focussed on calves reared with automatic feeders on a large commercial dairy farm in NSW following industry best practices.

Research approach

The aim of this research was to determine the factors affecting calf growth and if there's an opportunity to intervene to improve lifetime performance.

This research was 'farmer-led' in that the project arose from the farmer's observation of a relatively large, unexplained variability in the size of calves at weaning. Despite uniform management and adherence to best practice standards, there was concern that calves with problems were not always identified early enough for intervention or prevention of issues. The impact of this variability on lifetime productivity and profitability was not known.

Real-farm data underpinned the three studies in this research. On-farm records and the automatic feeders provided a rich data set including birth dates, weights at various ages, health indicators and feed intake.

The first and second study followed a cohort of 1,440 calves on reared automatic feeders.

The third study involved modelling, drawing upon a dataset of more than 14,000 calves.

Key findings
The first study looked at factors affecting the growth of calves reared with automated feeders. It found a wide variation (60kg) in weaning weight, despite a very low mortality rate (<0.1%). Birth weight, visitation and consumption had the greatest impact on weaning weight.

Underperforming calves on automatic feeders could be identified from day 5 in the feeder system (cumulative consumption), offering the opportunity for early management intervention.

The second study followed the long-term survival and lactation performance of the 1,440 calves in the milking herd. It looked at the association between weaning weight and future lactation performance (yield and number of lactations).

Of the 1,440 calves reared in the first study, only 55 reached their fourth lactation in the herd:

- 406 were removed between weaning and their first lactation (surplus to farm requirements or not in calf).
- 233 were removed after their first lactation.
- 392 removed after their second lactation.
- 354 removed after the third lactation.

A heavier weight at weaning translated to higher production (especially in lactation 1 and 2) and a longer life in the herd.

Weaning weight was more strongly associated with survival in the herd than birth weight. For example, a calf with a weaning weight of 50kg had a 17% likelihood of lasting three or more lactations in the herd, compared with 40% for a calf with a weaning weight of 100kg.

Weaning weight and cumulative consumption at day 5 had a significant impact on total lifetime milk production.

The third – modelling – study investigated the effect of preweaning factors on removal from the herd, using a dataset from more than 14,000 animals from the same herd.

Birth weight, weaning weight and days in milk significantly influenced the likelihood of a cow being removed from the herd. There were three points in the lactation where cows were more likely to be removed from the herd: early lactation (transition period), around 128 days in milk (not in calf) and after 305 days (long lactation cows). Cows with a lighter weaning weight were more likely to be removed from the herd early.

On-farm implications

This study quantified strong and positive associations between the performance of female dairy calves at weaning and their subsequent performance as lactating animals.

The findings provide the basis to develop early alert systems for calves being reared with automatic calf feeders.

This work is an example of the huge opportunity to use passive data collection from modern technologies such as automated calf feeders to improve farm management.

Progress update
This project is complete. The main outputs of the work are a PhD thesis, a paper in the Journal of Dairy Science and several others in preparation for submission.

Holstein steers for dairy beef

This project involves two studies to investigate the effectiveness of an integrated management strategy from Spain for rearing Holstein steers for the 'antimicrobial-free' beef market under Australian conditions.

The first study involved feeding Holstein steers (72) either a low starch (38%) diet with antimicrobials (monensin and flavophospholipol) or high starch (47.5%) diet for 452 days. They were evaluated for health, production, carcass measures and rumen function.

The second study looked at the differences between low and high performing steers over the 21 days of feedlot induction. Out of a population of 92 Holsteins, British and European breed steers, the 10 steers that gained the most and the 10 that gained the least for each breed (60 in total) were identified. Rumen samples were taken from these animals at feedlot induction and 14 days prior to slaughter. They are being evaluated for rumen microbiota, rumen fermentation markers, production, carcass and health metrics.

Key findings

Under good management, dairy beef can successfully reach 550kg carcase liveweight by 15 months of age, with or without the use of antimicrobials. The Spanish system may allow farmers to market their beef as antimicrobial free. However, the incidence of liver issues may increase. Antimicrobials have an important role in the beef industry.

Identifying poor performing steers at feedlot induction provides the potential for intervention to produce a healthier and more valuable steer.

Progress update

This project is ongoing. An honours thesis was produced for each of the studies. Manuscripts are currently in preparation.

Collaborators/funders

The P2e project is a collaboration between SciBus, the University of Sydney and Charles Sturt University, Meat & Livestock Australia and Church and Dwight.

Read more

S.W.J. Legge, P.C. Thomson, C.E.F. Clark, S.C. García (2022) Milk consumption and behaviour of calves in automated calf-feeders as early indicators of weaning liveweight, JDS Communications

H. Golder, J. Rehberger, A. Smith, E. Block, and I.J. Lean (2024) Shifts in rumen profiles of Holstein steers fed antimicrobial and starch diets. Journal of Dairy Science, Vol 107 (Suppl 1), pg 431 (abstract 2712)

More info

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Delivery organisations

Partner organisations

Additional program supporters, collaborations or partnerships

Charles Sturt University | DairyBio | DataGene | Eagle Direct | Entegra
Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Project Update
P2f: Infectious Diseases

May 2024

Diagnosing scours and respiratory diseases in calves

This project aims to determine the occurrence and spread of viruses and bacteria in NSW dairy herds. The information provides a foundation for tools to help farmers and vets monitor and treat diseases such as scours and respiratory disease.

Scours and respiratory diseases are common causes of death in young calves. Currently, calves with scours or respiratory disease are often treated on the basis of symptoms, without identifying the microbe responsible.

This project aims to build a genetic catalogue that can be used by diagnostic laboratories to improve their capacity for diagnosing pathogens causing disease and determine the most appropriate treatment.

This project is closely linked with Dairy UP's P2b project – Early Alerts.

Benefits

Early treatment, with the correct therapy is a critical step in avoiding the unnecessary use of antibiotics and preventing antimicrobial resistance.

Although this work is focussed on calf scours and respiratory diseases in NSW dairy calves, the findings have the potential for broader application. For example, the diagnostic tools developed may be relevant to dairy regions outside NSW.

The work will also enable early identification of new microbial variants or non-local variants that may have a significant impact on the industry.

Unlocking the potential of cows

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P2a: Cattle Longevity: Age and Parity & Intensive Herds*

P2a: Longevity: Future*

P2b: Early Alerts*

P2c: Milk as a Diagnostic Tool*

P2d: Facility Design for Cow Comfort *

P2e: Calf husbandry*

p2f: Infectious Diseases ('Infectome')

This document provides an update on P2f: Infectious Diseases.

This may be increasingly important in a future with extreme weather events as the ecological imbalances in the environment resulting from these weather events is predicted to further affect the occurrence of infectious diseases.

Research approach

The research team is using an approach called "metagenomics" to sequence and create a reference database of bacteria and viruses found in NSW dairy cattle. They aim to work with up to 80 dairy farmers from all of NSW's dairying regions to collect nasal and faecal swabs from sick and healthy calves. The bacteria and viruses detected in the swabs will be sequenced. These genetic sequences will allow scientists to identify specific 'strains' of bacteria or viruses that cause more severe disease than others and therefore guide the focus for disease control.

In future this information will be used on samples taken from sick calves for quick and easy detection of the virus or bacteria responsible for causing disease. This will enable early treatment with the appropriate drugs, improving survival rates and reducing overall use of antimicrobials.

A second part of this study will characterise E. coli, one of the most common causes of infection in animals and humans. This will help us understand the different genetic types of bacteria that infect calves, and the presence of antimicrobial resistance.

On farm monitoring

The Dairy UP team is collaborating with commercial dairy farms in NSW who have agreed to participate.

On the day the team visits, nasal and rectal samples are collected from calves up to 7 weeks old, including all sick calves and up to 10 healthy calves. In addition, samples are collected from up to 10 cows, that calved within the past 50 days.

Participating farmers are also asked to fill in a survey to gain insights into relevant management practices such as management of colostrum, bedding materials, nutrition, and calf rearing management.

Progress update (May 2024)

Pilot study
A pilot study involving two farms was completed in 2021. The results from this pilot study informed the design of the larger-scale on-farm monitoring work.

Initial analysis of samples collected from the pilot farms confirmed that scouring calves were mostly infected with pathogens consistent with their symptoms.

A variety of bacteria and viruses from the samples have been profiled. The results show the presence of known viruses, such as Rotavirus, Bovine coronavirus, Bovine torovirus and Bovine respiratory and syncytial virus. The team has also sequenced a number of viruses that have not been extensively studied, such as Kobuvirus, Hunnivirus, Norovirus, Calicivirus and Astroviruses. The next steps will determine if these viruses have a role in disease.

The sequence data in the pilot study also found some cases of high activity of bacteria such as Campylobacter sp. and E. coli in combination with viral infection.

The study will be able to estimate the prevalence of dozens of microorganisms across NSW dairy regions and help identify the potential genetic strains that are more likely to cause disease. These results will help improve diagnostics and guide the next research to develop efficient tools to prevent diseases in calves.

Farm sampling
As at December 2023, more than 2000 samples have been collected from 72 farms. The teams at EMAI and UTS are processing and sequencing samples and analysing and interpreting the data.

Project expansion

In early 2023, the team received an additional $434k in funding from the Australian Research Council's Linkage scheme. This funding is being used to expand the work on microbial surveillance to develop new tools for diagnosing causes of scours and respiratory disease in dairy calves.

PhD students

Two PhD students enrolled at the University of Technology Sydney (UTS) are working on the project.

Next steps

Priorities for 2024 include further analysis of samples and investigating new species identified and their potential role in dairy cattle diseases.

Collaborators

The P2f project is a collaboration between researchers from Dairy UP, UTS, NSW DPI Elizabeth Macarthur Agricultural Institute, and Scibus.

More info

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Delivery organisations

Partner organisations

Additional program supporters, collaborations or partnerships

Charles Sturt University | DairyBio | DataGene | Eagle Direct | Entegra
Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Project Update

P2g: Heifers Early Calving

May 2024

Unlocking the potential of cows

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P2d: Facility Design for Cow Comfort

P2e: Calf Husbandry

P2f: Infectious Diseases ('Infectome')

P2g: Heifers Early Calving

This document provides an update on P2g: Heifers early calving.

Why age of first calving matters

The age that dairy heifers calve into a milking herd for the first time can play a significant role in their health and welfare and the economics of a dairy farm business.

Australian dairy farmers with seasonal/split calving systems generally aim to calve their cows at about 2 years of age. In some Australian dairy herds, the actual age of first calving is closer to 3 years.

While it is possible to breed heifers to calve at less than two-years-of-age – and some dairy farmers do – there's limited research regarding the best age of first calving and what this means for the heifer across her lifetime and how this contributes to her return on investment.

Pros and cons of calving younger

The benefits of breeding Holstein dairy cows earlier have long been debated and weighed-up against the perceived risks of calving a heifer at a younger age.

The main benefits include earlier return on investment in breeding replacements, fewer unproductive animals on farm, improved lifetime production, improved reproductive performance, reduced generation interval (faster genetic gain) and marked reduced greenhouse gas (GHG) emissions intensity by producing more milk across an animal's lifetime.

Potential issues with calving cows younger include calving difficulties, fatty udder syndrome, lower production and joining poorly-grown heifers.

Demystifying the global research

Research has found that traditional concerns about calving heifers earlier, such as increased calving difficulties, fatty udder syndrome and decreased production, are largely unfounded, under optimum farm and animal management conditions.

For example, research has demonstrated an improvement in calving ease for heifers with an age of first calving of 18-22 months. Alternatively, those with an age of first calving at 26-months or more have an increased risk of calving difficulties – mostly attributed to a higher body condition score and excess fat. Fatty udder syndrome can be overcome if heifers are fed adequate protein in their diet.

Lower production in a heifer's first lactation – potentially due to earlier calving – also isn't a concern because her lifetime production is greater, and she has less "unproductive" time.

This project

This project is investigating the effects of age at first calving and other environmental influences on dairy cow longevity and lifetime production: including:

- Age at first calving and its effect on production, health and reproduction; differences between extensive and intensive systems.
- Hormonal and/or metabolomic influences at or around puberty.
- The effect of early breeding and calving on health, production and reproduction in the first lactation.
- Microbial enhancers used in compost barns to improve quality of bedding and its impact on cow behaviour.
- Effects of nutrition and environment on production, health and reproduction of housed cows.

This fact sheet reports on the early findings of the first point above investigations into the effect of age of first calving on production, health and reproduction.

Benefits

The findings from this research will provide a clearer understanding of what age is best for a Holstein heifer to calve for the first time.

This will enable dairy farmers to focus on growing-out their heifers – with optimum nutrition – to ensure they meet target breeding weight at this ideal age.

The findings should also provide clearer direction for the management of heifers and breeding plans, including fixed time AI programs.

In addition, this research should determine the return on investment for heifers and quantify the cost of "unproductive" animals on the farm – those that aren't producing milk.

Other benefits could also include understanding when to alter the age of first calving for improved economic returns. For example, when the farmgate milk price is low or if the cost of rearing calves is high.

Research approach

This project involves analysis of industry and herd data records, the collection and analysis of blood and feed samples, and controlled clinical trials with different housing systems.

A global literature review underpinned the first stage of this DairyUP project. Understanding the age of first calving in other dairy farming countries provided context for Australia's results and a guide for what's possible – including the economics of what a change in the age of first calving could mean.

On-farm research, across 6 farms is monitoring and comparing two groups of heifers bred at different ages. These heifers are being monitored throughout their pregnancy and for at least their entire first lactation, if not, their entire life.

On farm monitoring

This project is monitoring, and comparing, a total 429 Holstein heifers across two groups, bred at different ages, from 6 dairy farms. These dairy farms are already in the Dairy UP database and include 15 intensive operations – a mixture of free-stall and bedded pack barn – as well as 15 pasture-based operations.

The first heifer group was bred from 11 to 13 months-of-age and the second heifer group was bred from 13-15 months-of-age. All heifers were bred at a minimum 330kg.

In addition to monitoring the pregnancies of these heifers, additional testing includes reproductive tract scoring, targeted blood tests, and hormone influences. These blood tests will examine protein pathways, levels of the leptin hormone other hormones such as LH and IGF-1.

Progress update (May 2024)

The global literature review has found the average age of first calving around the world is generally 24 to 28 months. In the Australian Dairy UP database herd, the age of first calving for intensive dairy systems was about two years old or 24 months, slightly younger than pasture-based, extensive systems with a 26.5 months-old median age of first calving.

Researchers for the on-farm trials are awaiting heifer pregnancy confirmations. It's only early in the research but initial data suggested a higher pregnancy rate in the group of heifers bred at 12 months-of-age, compared to those bred at 14-months-of-age or older. Of heifer results on one farm, there were 76 heifers in the 12-months-old group, of which 56% were pregnant at the beginning of May. Up to 48% of the 54 heifers 14-months-of-age or older were pregnant at the same time.

Next steps

Priorities for the coming year include monitoring and collecting data on the heifers in the on-farm trial throughout their pregnancy, calving and first lactation.

PhD student

Andrew Lean

Collaborators

The P2g project is a collaboration between Dairy UP, Scibus, the University of Sydney and Charles Sturt University.

This project is closely linked with the following Dairy UP projects:

- P2a Cattle Longevity
- P2d Facility Design for Cow Comfort
- P2e Calf Husbandry

Further reading

Ettema, J. F., & Santos, J. E. P. (2004). Impact of Age at Calving on Lactation, Reproduction, Health, and Income in First-Parity Holsteins on Commercial Farms. *Journal of dairy science*, *87*(8), 2730-2742.

Hutchison, J. L., Null, D. J., Bickhart, D. M., Cole, J. B., & VanRaden, P. M. (2017). Genomic evaluation of age at first calving. *Journal of dairy science*, *100*(8), 6853-6861.

Krpalkova, L., Cabrera, V. E., Vacek, M., Stipkova, M., Stadnik, L., & Crump, P. (2014a). Effect of prepubertal and postpubertal growth and age at first calving on production and reproduction traits during the first 3 lactations in Holstein dairy cattle. *Journal of dairy science*, *97*(5), 3017-3027.

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Project summary

P3 Intensification of dairy systems | August 2023

Transitioning towards intensification

Internal and external triggers are leading some NSW dairy farmers to consider transitioning their businesses to more intensive farm feeding systems such as total mixed rations (TMRs), and housed facilities. Farmer surveys indicate that intensification in NSW is an adaptation strategy in response to climate variability and extreme weather events.

Motivations

Some of the reasons NSW dairy farmers consider intensification include:

- As a way to adapt their farming system to better handle climate variability and extreme heat or wet conditions.
- In response to changes in water policy, milk pricing and financial pressures.
- To help achieve goals for improving animal welfare, increasing milk and feed productivity, environmental sustainability, worker-friendly environments, and land access.
- To help achieve aspirations of control and consistency.

P3 Intensification of dairy systems

This project aimed to provide information to help farmers to decide if transitioning to an intensive production/feeding system is a suitable investment for their circumstances.

This work was complemented by a similar project undertaken in northern Victoria, led by Agriculture Victoria and Dairy Australia.

The findings from both the Victorian and NSW DairyUP project underpin the Farm System Evaluator, a tool that helps assess a dairy farm's readiness to change to a new farming system involving feeding and housing infrastructure.

Dairy UP's P3 project involved two areas of work:

- P3a: Economics of intensification (7 NSW case study farms)
- P3b: Social research to explore the drivers of change (including NSW case study farms).

This document provides a summary of findings from both areas of work which were completed by June 2023.

DairyUP Unlocking potential | NSW Government Department of Primary Industries | Dairy Australia

The intensification journey

A dairy farmer's journey towards intensification is context specific. Different farms have different starting points e.g., greenfield sites or incremental transitions.

The transition involves many incremental decisions such as purchasing more land, growing of crops and/or purchase of machinery.

Intensification brings new complexities in terms of deciding to invest, build and operate a contained housing system. These decisions require individual context with the support of regionally-specific information and advice, which can be challenging to find.

Pause points occur along the way such as:

- Planning - with councils for permits, selection of housing and effluent system, environmental plans
- Securing the capital for investments
- Liaising with council
- Construction of the housed system.

Management skills set

An intensive dairy system requires different management skills to pasture-based systems and has unique operational challenges. The following diagram identifies the key management skills challenges for farmers operating housed facilities, as identified by service providers.

Economic performance of NSW intensive systems

Intensive farm systems can be as profitable as pasture-based systems in NSW. Significant capital investment is required to develop intensive farm systems with housing and effluent management and the associated equipment needed to support the intensive system.

Intensive farms that were consistently profitable:

- Were well-established businesses feeding a TMR and/or managing the transition phase very well.
- Have strategic income diversification – gross farm income had a strong livestock trading component and/or feed sales.
- Tended to have very productive and efficient cows (kg MS/kg liveweight is > 100%).
- Managed feed sources very well – largely self-sufficient with fodder or a reliable external source such as unique by-products, regular feed testing and budgeting.
- Tended to have very good overhead cost control.
- Constantly looked to identify aspects of the business they could improve.

Collaborators

Dairy Australia | NSW Department of Primary Industries | The University of Melbourne

Read more

- **Dairy feedpads and contained housing: national guidelines**
- **Adapting Dairy Farm Systems | Dairy Australia**
  - including access to the 'Farm System Evaluator' decision support tool.
- **Economics of Total Mixed Ration Systems in Australia, Proceedings of the Australasian Dary Science Symposium 2022, p67-70**
- **Reichelt, N., Nettle, R., & Veskoukis, S. (2023).**
  Understanding the drivers of dairy feeding system intensification in NSW, including housed systems. Research report prepared for NSW DPI Dairy team, Rural Innovation Research Group, University of Melbourne.

For further information

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Delivery organisations: The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations: Norco | NSW Farmers Growing the best | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services

Project supporters: Charles Sturt University | DairyBio | Eagle Direct | Entegra | Macquarie University | smaXtec | UC Davis | University of Technology Sydney

Dairy UP (www.dairyup.com.au) is an industry driven R, D & E program led by the University of Sydney's Dairy Research Foundation (DRF) and co-delivered together with Dairy Australia, New South Wales Department of Primary Industry (both Agriculture; and Biosecurity Food and Safety; EMAI), and Scibus. The program is funded through a grant by the NSW Government (SDG scheme) with co-contributions from Australian Fresh Milk Holding Ltd., Dairy Australia, (formerly) Dairy Connect, Dairy NSW, DRF, Local Land Services (Hunter), Leppington Pastoral Co, Norco Dairy Co-Op, NSW Farmers, Scibus, and South- East Local Land Services.

August 23

Project Update
P4: Feedbase – Maize for Silage

February 2025

Unlocking the potential of maize

Dairy UP's P4 project aims to unlock the potential of the dairy feed base, with a focus on growing maize for intensive systems.

P4 is a project which integrates precision agriculture with real-time monitoring of plants and soils as well as advanced modelling to grow better forage crops and increase water and land-use efficiency.

This document provides an update on P4: Feedbase – maize for silage.

On most Australian dairy farms, the costs associated with feed represent at least half of all expenses associated with producing milk. Feed costs can be even higher for those milking cows in intensive Total Mixed Ration (TMR) systems or housed-cow operations. That's why any refinements to the feed base of a dairy farm can have a huge effect on a business' profit.

Maize silage

Maize is a key component in the feed base of many TMR or partial mix ration (PMR) systems because it is a high yielding and water efficient crop.

Several research studies, including projects through the FutureDairy program, proved the water and nitrogen efficiency of growing maize in Australia. Work with farmers across the country demonstrated that maize silage could consistently yield 25-28 tonnes of dry matter per hectare when good management was combined with good water and nitrogen availability.

In trials where maximum amounts of irrigation water were applied, maize silage yielded 5 tonnes of dry matter per megalitre of water – five-times greater than the average response to perennial pastures in the irrigation region of Northern Victoria.

With no water limitation, maize for silage also yields an average of 150kg of DM per kg of nitrogen.

The quality challenge

The ingredients that determine profitable maize crop yields are clear but ensuring it is then converted to 'high quality' silage isn't as straight forward – yet.

Maize silage is made from the entire plant. Each element has differing starch, fibre, and energy.

To confuse the matter further, metabolisable energy (ME) – a traditional form of determining feed quality – isn't an accurate indication of the quality of maize silage, as the high ME of the grain (starch) can be diluted by the lower ME of the stem and leaves.

Project aim

Ultimately, Dairy UP researchers want to create a decision support tool to help dairy farmers with their maize silage production. Ideally the tool would enable dairy farmers to accurately predict the quality and yield of maize silage. Through real-time monitoring of a maize crop, this tool would also allow dairy farmers to intervene throughout the life cycle of the maize plant to improve harvest potential. The tool would be underpinned by a modelling program called Agricultural Production Systems sIMulator (APSIM). Developed for other crops including maize for grain, a key focus of the Dairy UP work is to calibrate and test it for NSW maize crops for silage.

In parallel, the Dairy UP team is exploring other maize varieties, such as the highly digestible Brown midrib (BMR), and the interactions between genetics, the environment and management – exploring options for increased maize efficiency and profitability.

Benefits

Managed well, maize silage is an efficient use of water and nitrogen on-farm, but it's an expensive crop to plant. Tools to improve management can have a big impact on maize yield and quality and therefore the return on investment in the crop.

Understanding the potential yield and quality of the final, harvested silage will also help dairy farmers to plan in advance for their feed requirements and should decrease costs.

This work could also benefit other livestock industries that use maize silage as a feed source.

Progress to date (February 2025)

Yield and quality targets

A literature review together with the research helped establish maize silage yield and quality targets while also identifying knowledge gaps.

Maize silage targets include:

- Dry matter yield: 25t DM/ha.
- Starch: at least 35% to dilute as much fibre as possible.
- Harvest index (ratio of grain to total dry matter): 40-50% can dilute the fibre in maize silage.

Knowledge gaps include:

- Uncertainty about how to accurately measure the dry matter percentage of maize silage and if a maize silage with 35 per cent or more dry matter ensures a lower NDF due to increase in starch content.
- How much does sowing time, plant density, water and nitrogen availability determine crop yield and quality? And how can this be monitored in real time?
- How are indicators of silage 'quality' and yield best monitored?

APISM model calibration

The Dairy UP team has tested and calibrated a modelling tool Agricultural Production Systems sIMulator (APSIM) to predict the yield of a silage maize crop. The initial calibration was done with data from FutureDairy and the results have been published in the Frontiers of Plant Science Vol 14. The subsequent validation used data from maize crops on research (FutureDairy feedbase data) and six commercial dairy farms. The farm data was collected through remote sensing and real-time monitoring.

Overall APSIM predicts biomass of maize crops with reasonable accuracy.

The APSIM calibration has room for improvement in dryland conditions, but it provided reasonable predictions of yield and harvest index for irrigated crops across regions.

Figure 1: Data combined for 6 farms

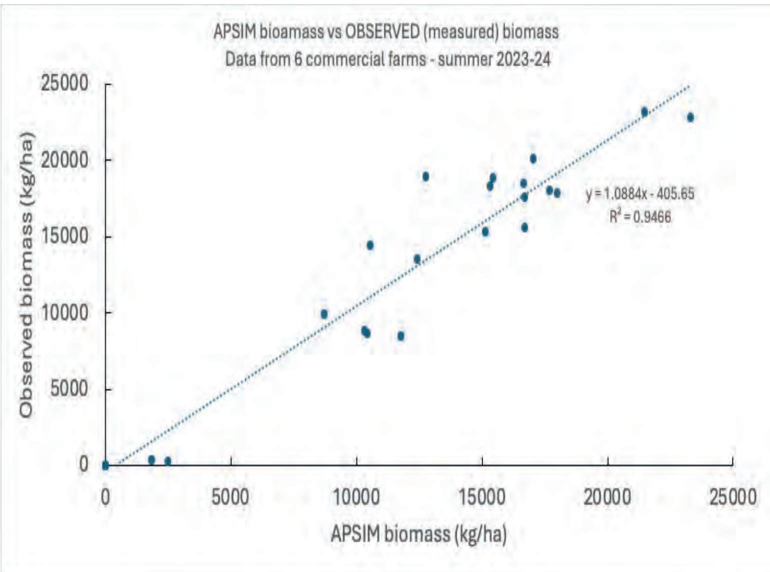
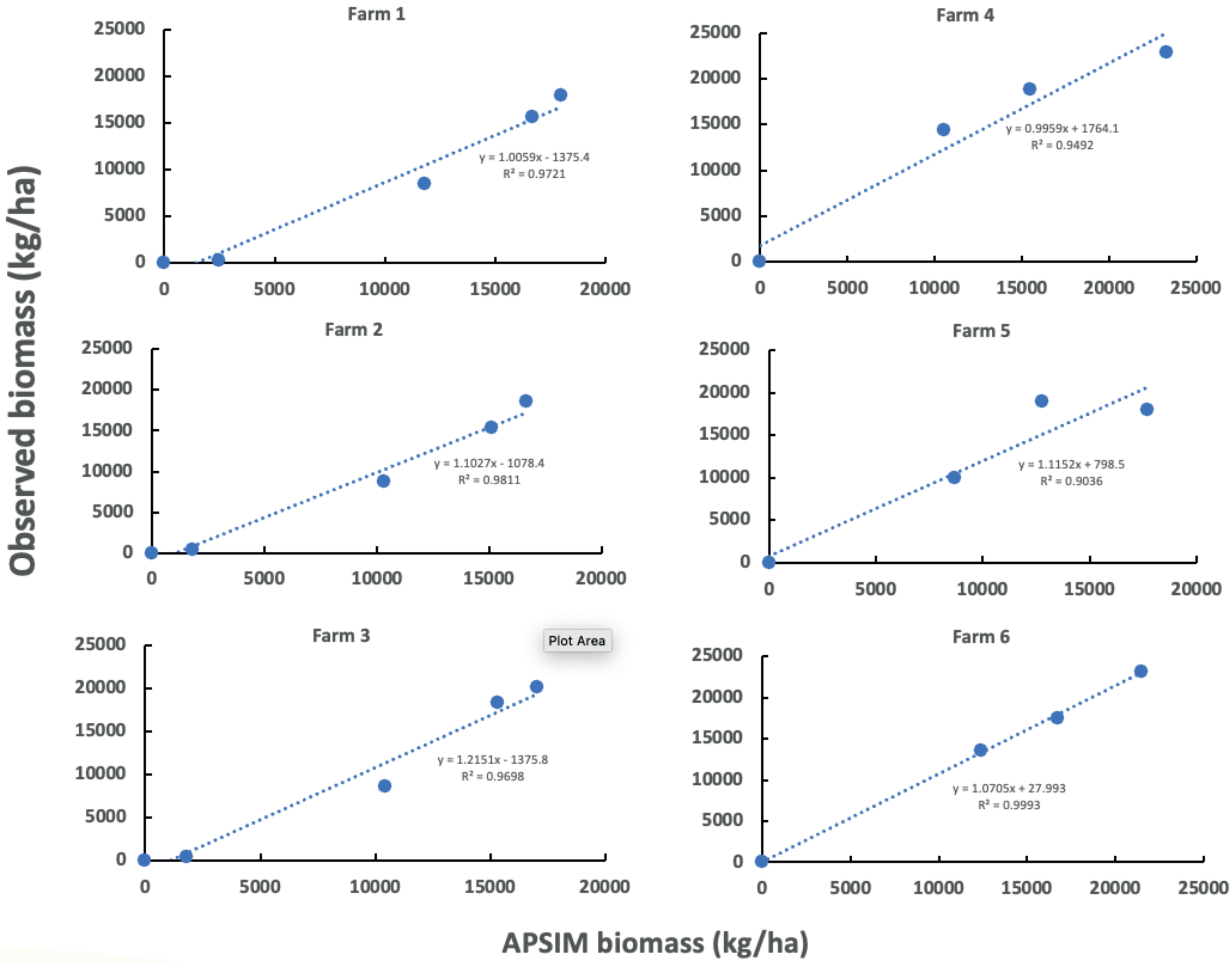


Figure 1 shows the combined data for the six farms.

Figure 2 shows the individual crop/farm data. It demonstrates good performance in all cases.

DairyUP
Unlocking potential

Figure 2: Individual crop/farm data



The challenge is the lack of gold standard data in terms of actual biomass and grain yield – This was measured through cutting plants but variation with paddock yield was high.

Nutritional value

<u>On farm monitoring</u>

In 2023, Dairy UP researchers evaluated 11 different maize silages across various NSW dairy farms to determine biomass, grain yield and the quality of the crop.

On average, grain in the maize silage was 78% starch and 14 MJ/kg DM, however, there was variation between the different maize cultivars.

Neutral Detergent Fibre (NFD) percentages varied across the rest of the plant. The cob (without the grain) was 70% NDF, while the leaf and stem were at least 60% and the grain was 8%.

Metabolisable energy (ME) of the grain was 14 MJ/kg/DM, while the rest of the plant was 8 MJ/kg DM or less.

Next steps

<u>University of Sydney farm trials</u>

The team is currently collaborating with Pioneer Seeds to evaluate yield and nutritional characteristics of conventional and 'brown mid-rib' (BMR) hybrids grown under full irrigation at the University of Sydney "Lansdowne" farm at Camden. They are also collaborating with the Australian Plant Phenomic Network (APPN), based at the University of Sydney, to monitor how maize performance is influenced by genes and environmental conditions.

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The project is using drones and advanced technologies.

The findings will provide insight into the extent of nutritional differences of BMR, as well as testing the ability of satellite and APSIM models to predict those differences.

The goal is to integrate APSIM with satellite data to improve yield and quality predictions as well as dairy farmers' ability to monitor, and intervene, in the plants' growth, in real-time.

This should provide the knowledge base to develop a decision support tool.

Read more

Ojeda, JJ et a;. (2023) Field and in-silico analysis of harvest index variability in maize silage. Frontiers in Plant Science Volume 14

More info

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Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

Additional program supporters, collaborations or partnerships

Charles Sturt University | DairyBio | DataGene | Eagle Direct | Entegra
Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Project Update
P5: Our Farm Our Plan

February 2024

Planning for success

In 2020 the Australian dairy industry launched an initiative called “Our Farm, Our Plan” to help dairy farmers set long term goals, improve business performance, and manage risk.

Central to this program is the development of a strategic plan including business and personal goals.

Within Our Farm, Our Plan, a strategic plan has been known as a ‘plan on a page’ – a one page document that’s developed by farm business managers, with assistance from industry consultants – that provides direction by outlining goals and practical steps to get there.

It's a document that helps dairy farm businesses plan for success.

Potential benefits

Clear, long-term business and personal goals help farmers and farm businesses identify and prioritise actions, manage uncertainty, mitigate risks, and capture opportunities.

These goals – and the consultation, deep and strategic thinking required to develop them – enable business owners a unique insight into themselves and their business.

From this, they get a better understanding of their current business position, including its strengths and weaknesses, and can set a direction for the farm business.

Clear business direction is a great way to boost morale and involvement, stay on track and check progress.

An effective strategic plan also helps a business deal better with challenges or unexpected hurdles, such as changes to operating environments and climate risks.

Looking into the future

The Dairy UP team is working with industry organisations to increase the proportion of dairy farmers in NSW with effective strategic plans to help clarify long-term business and personal goals.

Successful businesses have a strategic plan that describes goals and a plan to achieve them including practical steps.

This plan helps a business manage risk and improve its performance by encouraging reflection and a proactive business culture.

It’s also a great tool for recovering from adverse events such as bushfires or droughts.

Our Farm Our Plan is a Dairy Australia initiative. It is delivered in NSW through Dairy NSW, Subtropical Dairy, Murray Dairy and Dairy Australia as part of the Dairy UP program (P5).

A strategic plan is a good fit with businesses recovering from adverse events such as bushfire recovery or drought.

It also helps with investment decisions, succession planning, staff recruitment and retention as well as implementation of technology and much more.

For the dairy industry, a big part of Our Farm, Our Plan is to upskill local consultants.

This will enable farmers have access to assistance quicker than flying in interstate consultants following adverse events.

Strategic approach

Our Farm, Our Plan provides a framework for identifying goals, planning, evaluation and action steps.

It equips dairy farmers with the skills and knowledge to apply strategic thinking and planning processes to achieve their agreed business and lifestyle goals.

As part of the planning process, farmers outline their business direction – including goals – assess their current position and business risks, identify, and prioritise options, understand risk management principles, records access farm performance data and develop communication skills.

Feedback

The workshops have delivered more to dairy farmers than strategic planning skills. Feedback from dairy farmers about the workshops highlighted the benefits of meeting fellow farmers while developing a useful planning tool for their farm business.

Progress update (November 2023)

Thanks to Dairy UP, 130 farmers have participated in Our Farm, Our Plan workshops and one-to-one sessions delivering more than 60 individual plans across 22 workshops.

This is a high proportion of the industry compared to other dairying states.

A breakdown of the Dairy UP roll-out since July 2021 includes:

- Eight face-to-face workshops
- Two intensive workshops
- Three workshops focused on the next generation – those looking for a career path – through the Young Dairy Network (YDN)
- Nine national online opportunities

Next steps

Dairy UP’s P5 Our Farm, Our Plan runs until June 2024.

Encouraging farmers to complete strategic plans will continue to be a priority.

More recently, seasonal challenges in NSW have plagued the dairy industry and as a result it has been challenging to recruit participants to complete the Our Farm Our Plan sessions.

For more information, or to register for face-to-face or online events, visit the links below.

Registration is essential.

Dairy NSW Our Farm, Our Plan: Hunter Valley April

Register by clicking: https://bit.ly/OFOPHunter2024

Our Farm, Our Plan National Online February 2024

Register by clicking: https://bit.ly/42xd4lx

or

National Our Farm, Our Plan National Online May 2024

Register by clicking: https://bit.ly/3SPvquL

Collaborators

Delivery of Our Farm Our Plan in NSW involves collaboration between Dairy UP, Dairy Australia. Dairy NSW, Subtropical Dairy and Murray Dairy.

More info

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Project Update
P6: Future Systems – Dairy DaTA

October 2023

Fit with Dairy UP 10 projects

Dairy UP's P6 project is exploring ways to use existing farm, climate and industry data to develop ways to monitor cows and systems to help farmers make better decisions, for example about heat management, health and feeding. One aim is to support animal and environmentally friendly intensification.

P6 is a suite of three projects that combine animal science and data science. Each project is being undertaken by a PhD student.

- P6a: Resilient Cattle (heat tolerance): optimising on-farm energy use and cooling systems.
- P6b: Resilient Cattle (health): early intervention for improved animal health, enabled by advanced sensing.
- P6c: Digital Feeding – data-driven feeding to optimise grain allocation in pasture-based herds.

This document provides an overview of the three projects.

Data, Advanced Technology and Automation (DATA)

Copious volumes of data are collected across the Australian dairy industry. Until now this has been stored in numerous, separate data bases.

This project aims to utilise data, advanced technologies and automation to integrate information from multiple sources to enable the creation of tools that support on-farm decisions.

P6a Resilient Cattle (heat tolerance)

Dr Anna Chlingaryan and Alice Shirley, PhD student

Managing dairy cattle in hot, humid conditions is an increasing issue for the Australian dairy industry with climate change and the increasing intensification.

This project explores the diversity in response by dairy cattle to heat events. It uses new sources of data (core body temperature) and new methods (machine learning) to help manage cows in hot, humid conditions.

Progress: October 2023
Cows on three Australian pasture-based dairy farms have been fitted with rumen sensors (reticuloruminal boluses) to monitor core body temperature, every 10 minutes, 24 hours a day. A water threshold model has been developed to account for water intake, isolating the impact of drinking events on core body temperature. This model will soon be validated on a fourth dairy farm.

The team is currently exploring:

- individual cow variability in response to climate
- the association between the Heat Tolerance Australian Breeding Value (ABV) and a metric that will be developed using core body temperature data.

New South Wales climate data from the past 20 years has been obtained from the Bureau of Meteorology.

The Dairy UP team has examined the current method for measuring heat tolerance in cattle. A pre-processed historical herd test dataset supplied by DataGene was merged with climate data at the postcode level. A novel machine learning-based approach has been developed to improve the calculation of heat tolerance. This machine learning approach is more versatile and robust in modelling a wide range of relationships between milk production, climate variables, and cattle characteristics.

The new methodology may enable a more reliable identification of cattle that are resilient to climate variation and extreme events.

The next steps in this project include:

- Validation: checking that animals identified with the developed methodology are in fact more heat tolerant.
- Working with Dairy UP's P2 project team to explore opportunities for housed cows.

P6b Resilient Cattle (health)

PhD student: Maddi Perce

The number of dairy cattle housed indoors in Australia is increasing with the trend towards intensive systems.

Intensively housed animals can be fitted with sensors (in and on the animal) to monitor behaviour in near-real time.

This project aims to develop a model for predicting health issues by combining data from animal sensors with other farm records. This would enable early intervention to either prevent or reduce ill-health.

Progress: October 2023
The Dairy UP team has obtained sensor and health data from a large, intensively-housed herd in NSW.

The next step is to use machine learning techniques to create models of reduced health.

P6c Digital Feeding

PhD student: Blessing Azubuike

This project is investigating ways to use data to guide grain allocation decisions for pasture-based herds with automatic feeders.

The project builds upon earlier work by the University of Sydney that found the potential for a 10% increase in milk production through improved feed allocation to individual animals.

It is drawing upon existing farm data to create a "digital twin" model for optimised, automated, grain feeding.

The digital twin model approach creating a digital version of a living animal that can be applied to optimise biological functions and processes.

Future applications of this approach could be for optimising calf rearing, cow production, reproduction efficiency, cattle health and survival.

Progress: October 2023
A model has been developed that uses the same total daily concentrate budget as flat rate feeding but achieves about 12% increase in milk yield by customising the daily concentrate allocated to each cow.

The model 'learns' the features of individual cows – for example, it's production response to daily concentrate fed – and prescribes concentrate allocations accordingly.

Similar estimated responses were achieved for a commercial farm that is monitored by the Dairy UP project. It showed the potential of an 8% increase in total milk yield production when incorporated with weather data and cow characteristics.

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Next steps

The next steps involve:

- Exploring the impact of pasture utilisation on the optimum allocation of grain-based concentrate on pasture-based dairy farms.
- Developing a model to optimise the approach at the herd level and adapting it to work on commercial farms.
- Testing the optimisation model on a commercial farm by collecting real-time data that will be used for evaluating the models' performance analysis.

More info

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Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

Additional program supporters, collaborations or partnerships

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Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Project Update

P6a: Resilient cattle (heat tolerance)

December 2024

P6a Resilient Cattle (heat tolerance)

Managing dairy cattle in hot, humid conditions is an increasing issue for the Australian dairy industry, with climate change and the trend towards intensification.

Under the supervision of Dr Anna Chlingaryan, Dairy UP PhD student, Alice Shirley, is exploring the diversity in dairy cattle responses to heat events. By collaborating with DairyBio and DataGene, the outcomes of this work will contribute to developing an improved tool for breeding dairy cattle with improved heat tolerance.

Heat Tolerance ABV

Published by DataGene, the Heat Tolerance Australian Breeding Value allows farmers to identify and breed animals with greater ability to tolerate hot, humid conditions with less impact on milk production.

The current Heat Tolerance ABV is derived from genomics only – the DNA testing of animals. It has a relatively low reliability which has contributed to slow uptake by farmers.

The Dairy UP project aims to develop phenotypes for heat tolerance to add to the model for the Heat Tolerance ABV. Phenotypes are indicators of animal performance that can be measured in commercial animals. Combining genomics with traditional and new measures of heat tolerance should improve the reliability (accuracy) of the Heat Tolerance ABV.

Data, Advanced Technology and Automation (DATA)

Dairy UP's P6 project is exploring ways to use existing farm, climate and industry data to develop ways to monitor cows and systems. Reports and tools based on this data could be used by farmers to make better decisions, for example about heat management, health and feeding.

Copious volumes of data are collected across the Australian dairy industry. Until now this has been stored in numerous, separate data bases.

This project aims to utilise data, advanced technologies and automation to integrate information from multiple sources to enable the creation of tools that support on-farm decisions.

P6 is a suite of three projects that combine animal science and data science. Each project is being undertaken by a PhD student.

- P6a: Resilient Cattle (heat tolerance).
- P6b: Resilient Cattle (health): early intervention for improved animal health, enabled by advanced sensing.
- P6c: Digital Feeding – data-driven feeding to optimise grain allocation in pasture-based herds.

This document provides an overview of Project P6a Resilient Cattle (heat tolerance).

Enhancing phenotype calculation

(Dairy UP)

Dairy UP is developing a hybrid artificial intelligence (AI)-based model (HAIM) to improve the assessment of heat tolerance in dairy cattle.

The aim is to enhance the heat tolerance phenotype calculation using machine learning techniques and 20 years of historical climate and dairy cattle production data.

Traditional methods for determining heat tolerance in dairy cattle involve statistical models that use the rate of decline in milk yield as Temperature-Humidity Index rises above 60. The developed HAIM combines the predictive capabilities of machine learning algorithms with these established statistical models, allowing for the detection of intricate relationships within the extensive data. The HAIM has the potential to reveal patterns that might remain hidden when using traditional models alone, enhancing the understanding of heat tolerance in dairy cattle and the identification of more heat-tolerant animals.

Collecting phenotypes with sensor technology (Dairy UP)

Dairy UP is using innovative sensor technologies to extract value from data sources data (core body temperature) through advanced methods (machine learning).

Artificial intelligence is being used to build animal datasets to improve the understanding about which animals are more susceptible to heat.

Cows on three Australian pasture-based dairy farms have been fitted with rumen sensors (reticuloruminal boluses) to monitor core body temperature, every 10 minutes, 24 hours a day.

A water threshold model has been developed to account for water intake, isolating the impact of drinking events on core body temperature.

A total of 1429 animals were involved in this research, plus 28 heifers from the University of Sydney farm in NSW.

In addition, climate data from the past 20 years was obtained from the Bureau of Meteorology to match the observations from the cows.

Progress: October 2024

Two experiments are completed, and further research has been flagged.

Results confirmed significant variation between animals' reticulorumen temperature (core body temperature) and their drinking behaviour over time. This work also demonstrated the core body temperature of cattle increased at lower Temperature and Humidity Index (THI) levels than previously thought.

For example, the rumen sensors were indicating a rise in core body temperature at 67 THI. Until now, it has been recommended that herd managers prepare for a heat stress event at 70 THI, with negative effects on production expected at 75THI.

The research also confirmed that cows drink more often during summer and less in winter. As expected, cows in herds in warmer regions also returned to the trough to drink more times, on average, in a day compared to those in cooler climates.

A limitation to this study was that drinking events were included and as such affected by the temperature of water as the cow drinks.

Next steps

In further analysis, drinking events will be removed from this data to determine the effect of heat on the core temperature of pasture-based dairy cattle.

This information will be analysed with climate data from Bureau of Meteorology (BOM) stations to fill knowledge gaps and develop a better understanding of the link between cow behaviour and the weather.

The team will also collaborate with smaXtec – an animal health software company – to include data from more animals.

Combining phenotypes and genotypes

(DairyBio)

This collaborative project is being undertaken by DairyBio and La Trobe University PhD student, Laura Jensen under the supervision of Professor Jennie Pryce.

This project is combining the genetic and performance data from animals with a variety of approaches including the sensor technologies from the Dairy UP project.

This information may allow the model for the Heat Tolerance ABV to be extended to incorporate sensor phenotypes which could help to identify animals that better tolerate hot and humid conditions with less impact on their milk production.

Sensors are one example of new research methods that could improve how we select for heat tolerance, capturing its full complexity. Success in this area will come from collaboration among animal scientists, combining genomics with traditional and new measures of heat tolerance.

Collaboration

Dairy UP
DairyBio (Victorian Government)
DataGene
Charles Sturt University,
SmaXtec
University of Sydney

Published articles

Shirley A. K. et al (2024) Review: Ruminant heat-stress terminology. Animal Volume 18, Issue 9.

Pryce Jennie E., et al (2022) Impact of hot weather on animal performance and genetic strategies to minimise the effect. Animal Production Science 62, 726-735

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Delivery organisations

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Partner organisations

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DAIRY BUSINESSES FOR FUTURE CLIMATES

MID-NORTH COAST NEW SOUTH WALES

KEY FINDINGS

Options to manage climate impacts in 2040 were analysed for a case study farm on mid-north coast of NSW.

The feedbase (mix of temperate and tropical pastures and crops), was quite resilient to the changed climate.

Heat stress on cows will be a key issue in the 2040 climate for this farming region.

Milk production was predicted to decline by 3-4% by 2040.

If no changes are made to the case study farm, annual operating profit is predicted to decrease by about 20% under 2040 climate.

None of the development options analysed were clearly superior to the others. All have positive and negative features.

Profitability of all options analysed were negatively affected by the 2040 climate change scenarios.

The Adapt option (shade and feedpad) enables better heat stress management in 2040 with moderate capital investment.

Dairy farm managers will need to continue to adapt their farm systems to manage risks.

Aim of the case study research

To explore how dairy farm systems in the mid-north coast region of New South Wales (near Kempsey) might perform under predicted climate changes (out to 2040) and how they could adapt to a changing climate.

A dairy farm near Kempsey was selected as a case study farm, supported by a reference group of farmers and service providers. Three development options for the base farm (case study farm) were modelled in a 2040 climate by an economist and biophysical modellers.

Changes in 2040

- Temperatures will increase by 1.0°C (from 1990-2009 base period).
- Heat stress is predicted to increase in 2040, and milk production to decline by 3-4% for the base farm.
- Predicted to be little change in total annual rainfall but with a 5% decline in winter, 10% increase in autumn and little change to summer rainfall.
- Fewer, larger rainfall events are expected, with longer dry spells in between.
- Pasture feedbase is quite resilient to the predicted climate changes in 2040 (and more so than in southern Australia where climate change is predicted to lead to a contraction of the pasture growing season, lower pasture production and grazed intake).
- Monthly average pasture growth rates were predicted to increase in autumn and winter but decline slightly in late spring.

Base farm:		
• 230 milking cows • Year-round calving (except summer months) • Grain feeding 2 t/cow per year • Production of 535 kg milk solids/cow per year • Feedbase mix of temperate and tropical pastures and crops.		
Three development options explored:		
Option 1: Feedlot	**Option 2: Adapt**	**Option 3: Simplify**
• 300 milking cows with an increase in milk solids/cow • Freestall barn, no grazing • Invest in a barn, effluent system and machinery • Year-round calving • 3 t concentrate/cow per year.	• 230 milking cows (same as base farm) • Shade infrastructure and concrete feedpad • Cover yard at the dairy • Increase cow intake, production per cow and less wastage • Keep feedbase and operating costs similar.	• Decrease to 180 milking cows • No capital investment in infrastructure • Split calving pattern to 66% in autumn and 33% in spring • 1 t concentrate/cow per year • Feedbase changed to more perennial pasture to fit calving pattern.

What differences did we find between the options?

The predicted profitability of the base dairy farm business and all three development options was lower than current under the 2040 climate change scenarios modelled.

None of the development options analysed were clearly superior to the others. All options have positive and negative features and the profitability of all are sensitive to milk price. The Adapt option appears to enable better heat stress management in the predicted 2040 climate without such substantial capital investment as the Feedlot option. The most suitable option will depend on resources available to the business and the long-term plans and goals of the people involved.

In the Base farm and Simplify option, where no additional infrastructure was provided, milk production was predicted to decline by 3-4%. But for the Adapt and Feedlot options, with shade infrastructure, the reductions in milk production were predicted to be 1% and 1.5% respectively, with the high-producing feedlot-cows being more susceptible to heat stress.

Feedlot option

- Higher variability in profit/risk than the other options and predicted profit would not justify the additional risk if the average milk price was $8.00/kg milk solids or less.
- Higher exposure to supplementary feed prices means this option is impacted by dry periods (with high imported feed prices).
- A high and stable milk price makes this option a more attractive investment.
- Obtaining planning approval for a feedlot is likely to be difficult in this location.
- Higher initial equity is important for this option.

Adapt option

- The Adapt option was least impacted by 2040 climate due to better infrastructure to manage heat stress with lower capital investment than the Feedlot option.
- Reasonable strategy to mitigate heat stress with moderate capital investment.
- Little difference between the profitability of the Base Farm and the Adapt option in the Historic climate.

Simplify option

- While the % return is comparable to the Base Farm, the annual operating profit is smaller which would impact on ability to service debt and grow the business.
- Other risks are reduced.
- Performs relatively well in dry periods with high supplementary feed prices due to lower exposure to the supplementary feed market.

This case study provides some indicative data for the region, but care needs to be taken about making regional generalisations from individual case study farms. For this region, most of the impact stems from increased heat stress impacting milk production. Other regions around Australia, where case studies have been conducted, are more affected by reduced pasture/crop production.

Successful implementation of all options will be heavily dependent on excellent management skills.

In addition to 2040 climate impacts, 'one-off' events such as a large flood or bushfire can be very costly to farm businesses but are difficult to represent in the modelling and should be considered where possible in future planning decisions.

Project Update
P8: Farmer Capability

April 2024

Farmer capability

Dairy UP's P8 set out to help NSW dairy farm businesses and their workforce develop their capability in compliance and management.

Completed in June 2023, this was a collaborative project with Dairy Australia, with NSW activities delivered by Dairy NSW. Dairy Australia is continuing to expand its resources and delivery activities in this area, as part of its People in Dairy portfolio.

This document provides a summary of the work delivered for NSW under the Dairy UP banner.

Australian dairy businesses face ongoing challenges in sourcing and keeping people with the skills needed to work on farms.

The issues existed before Covid but escalated during and after it. Dairy Australia research found that 58% of dairy workers who resign move to a role outside the dairy industry. It identified issues around both attracting and retaining people working in the industry.

This project aimed to enhance retention by building the skills and capabilities of the current and next generation of dairy farmers, both employers and employees.

It delivered a series of one-on-one consultations and developed a suite of resources.

One-on-one consultations

A one-on-one consultation package was developed and tested for upskilling farmers in HR and people management. It involved on-farm visits by a specialist HR consultant to provide guidance to improve HR management and skills, particularly in compliance and safety.

Seventeen NSW farmers participated in one-on-one consultations through the project. Upon completion, they reported increased reported confidence to manage HR issues (rising from 6.1 to 8.2 out of 10).

Resources

The project developed/updated a suite of training resources for farmers focussing on human resources (HR), safety and developing people capability.

These resources have been pilot tested, refined and incorporated into Dairy Australia's online training platform (Enlight) - which is available to all Australian dairy farmers.

The project created the content for 'Building your farm system' which covers chemical handling, quad bikes, introduction to farm safety and confined spaces.

The 'Managing People' course was completed and uploaded to Enlight following two online pilots. Farmer feedback is that it helps them develop valuable skills such as consideration of different learning styles thus creating more efficient and engaged workplaces contributing to increased retention.

The Employment Basics course was finalised following a lengthy review including survey of past participants and two pilots. The course directly supports compliance with IR legislation thus encouraging employee attraction and retention.

Next steps

DA has since made significant investment through its Workforce attraction project that funded delivery of these programs in NSW.

Collaborators

Dairy UP, Dairy Australia

Read more

Dairy Australia's Farmer Capability Guide

Dairy Australia Employment Basics training package

Dairy Australia Managing People training package

More info

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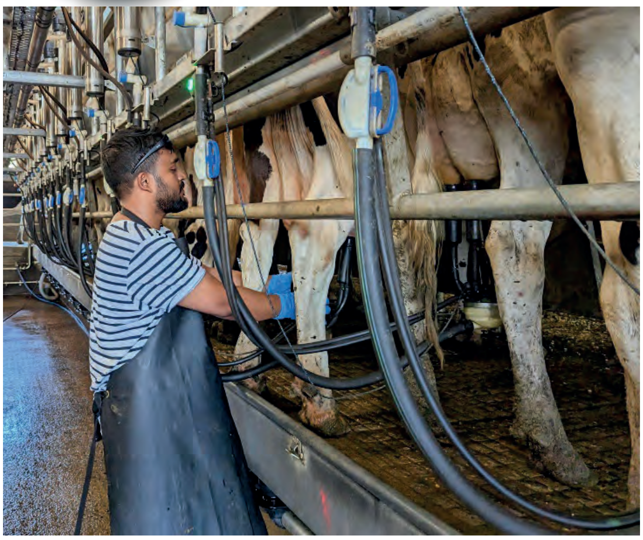
Project Update
P9a Producing milk with less lactose

February 2025



Unlocking the potential of cows

Milk underpins the dairy industry. Getting more from this precious commodity has the potential to increase its value throughout the supply chain.

The Dairy UP team is investigating novel ways to get more value from milk.

There are three elements to this research:

P9a: Producing milk with less lactose

P9b: Milk as an indicator of heat load

P9c: Adding value to dairy waste

This document provides an overview of P9

Climate change is increasing pressure to produce food with less water. As milk is 87% water, producing milk with less water is an opportunity for the dairy industry to improve its carbon footprint, reduce energy costs and improve water use efficiency. This could create more value and profit along the supply chain.

This project aims to find ways to produce cows' milk with high concentrations of solids.

Lactose is the focus of this work as it plays a key role in determining milk's water content.

The project is investigating the theory that those cows that produce less lactose would produce milk with less water and higher concentrations of solids.

Potential benefits

Lactose has broad roles in the physiology of the dairy cow, which means the potential to influence lactose production has a wide range of potential benefits.

Animal performance, health and welfare
It takes a lot of energy for a cow to produce lactose so reducing the production of lactose could improve the energy balance of the cow, especially during the transition period. Improved energy balance could also have a role in reproduction and fertility.

Lactose is also associated with some animal health traits. For example, milk lactose content could be used to monitor or detect mastitis and ketosis in dairy cows.

Farm labour
If reducing lactose production means cows produce milk containing less water, it may be possible to reduce the frequency of milking. This could provide a labour-saving opportunity.

Processing and transport
A reduction in milk volume could also lead to more efficient transport – carting less water or volume overall – and gains in the processing sector.

This project

This project builds on earlier work in California led by Dairy UP collaborator Prof Russ Hovey that demonstrated it is possible to reduce the lactose in milk production without negatively affecting the total milk solids output. To identify potential management interventions to reduce lactose production, DairyUP researchers are investigating the factors that influence lactose secretion in the cow, for example milk composition, genetics and environmental conditions.

There are two elements of this project. The first project is investigating the impact of genetics and other management or environmental influences. It involves analysing data from Dairy UP monitor farms, NSW herd test results and DataGene's Central Data Repository.

The second is research to better understand lactose synthesis in the dairy cow and how it is regulated. This work is being undertaken at the University of California, Davis, USA.

Genetic, management and environmental influences

Results to date show significant variations across breeds, lactation stages, parity (number of calvings) and seasonal conditions. Researchers have been able to identify cows that consistently produced milk with reduced lactose content or lactose yield while maintaining similar fat and protein levels.

These findings indicate there could be opportunities to improve milk production efficiency by enhancing milk composition and reducing water content.

Research approach

This work involved examining datasets of herd records, genetic data for dairy sires and meteorological records. Spanning 14 years (2008-2022) the dataset included 393,772 herd records from 33,280 cows in 85 herds, representing 5% of the NSW herd records.

The following summarises some of the high-level findings about the factors affecting lactose production in Australian dairy cows.

Parity (number of calvings)

The lactose percentage was higher for heifers throughout their lactation but their total lactose yield wasn't.

Stage of lactation

Stage of lactation had a strong impact on lactose output, peaking in early lactation and decreasing as the lactation progressed (similar to the milk yield curve).

Seasonal conditions

Hot, humid weather negatively affected yield of milk, lactose and milk solids but it did not affect lactose percentage or other milk components. A decline in milk yield lactose yield and protein yield coincided with severe drought conditions from 2016.

Breed

Holsteins had the highest lactose yields. Jerseys had the lowest lactose yields produced more milk solids per unit of lactose. This finding wasn't surprising given that Jerseys are well recognised for producing milk with higher concentrations of solids for a given volume of milk compared with other dairy breeds like Holsteins.

Genetic link

Building on these findings, DairyUP researchers uncovered a genetic link for the NSW cows that produce less lactose.

Investigation of bull Australian Breeding Values (ABVs) demonstrated low lactose producing cows were descendants from 13 sires (mostly Jerseys).

All the daughters (or descendants) of these sires produced a similar milk yield, but with more fat, and showed a trend towards lower protein production. There was no difference in daughter fertility.

Implications

These findings highlight the potential for selective breeding for cows that produce less lactose and more milk solids and less milk volume.

The findings also highlight the potential to develop management strategies to influence lactose production and enhance the milk production efficiency of cows and potentially reduce their environmental impact.

Lactose synthesis

A 'proof of concept' study has shown it is possible to change the proportion of lactose in milk without affecting fat and protein production.

The study involved Holsteins in a total mixed ration farming system that were on their second calf and at peak lactation.

It demonstrated that a single treatment with the drug dexamethasone temporarily reduced the amount of lactose in the cow's udder. Fat and protein production increased in response to the treatment as milk volume decreased.

The team has uncovered a possible explanation for this finding. Advanced genetic testing pointed to a regulatory molecule involved in lactose synthesis (alpha-lactalbumin) that was suppressed by the dexamethasone treatment

This finding offers new insights for researchers to better understand the factors regulating milk yield (volume) relative to the fat and protein content which could lead to interventions. This work was published in Frontiers in Genetics (https://www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2022.1072853/full)

Next steps
The next phase will involve working with Dairy UP farm data and additional data from NSW farms to conduct an in-depth analysis of cows that have shown reduced lactose production and milk volume and higher milk solids.

Collaborators

This project involves collaboration between Dairy UP researchers based at the University of California Davis (USA), DPI NSW and the University of Sydney. A large proportion of the herd records were provided by DataGene.

Read more

Gargiulo, J.I., S.C. Garcia, and R.C. Hovey (2025) Sources of Variation Underlying the Production of Lactose by Dairy Cows https://https://www.journalofdairyscience.org/article/S0022-0302(25)00068-2/fulltext

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Project Update

P9b: Milk as an Indicator of Heat Load

December 2023

Milk samples could give insights about a cow's level of heat load, offering an easy-to-access management tool to guide animal welfare decisions by dairy farmers.

This would be a non-invasive alternative to testing though blood and saliva. There's also less room for error or subjectiveness compared to visually assessing a herd for heat load. Additionally, it has the potential for remote monitoring and could be a service offered by milk processors.

This project is investigating the potential to use the level of the 'heat shock protein' HSP70 in milk as an indicator of heat load in dairy cattle.

Getting more from milk

Milk underpins the dairy industry. Getting more from the precious commodity has to potential to increase its value throughout the entire supply chain.

The Dairy UP team is investigating novel ways to get more value from milk.

There are three elements to this research:

- P9a: Producing Milk with Less Lactose
- P9b: Milk as an Indicator of Heat Load
- P9c: Adding Value to Dairy Waste

This document provides an overview of P9b.

Progress (December 2023)

Studies to date have confirmed that milk HSP70 levels could be used as an indicator of heat load.

Dairy UP researchers have modified and adapted an "in-house" ELISA test to detect HSP70 in milk, blood and saliva samples. The method was initially developed by Dr Indunil Pathirana in a collaboration with the Dairy Research Foundation.

ELISA is a laboratory testing technique that detects certain proteins, antibodies, hormones and much more. This ELISA test is cost effective and detects a broader range of HSP70 than commercial kits.

Findings so far show that the ELISA test can detect heat stress in milk, but levels are lower than in blood or saliva. The lower levels do not necessarily mean lower accuracy – and confirming this is the next step for the project.

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Dairy UP research already showed that HSP70 can be detected in milk for up to 9 days if samples are stored in the fridge, with or without a preservative, or for up to 90 days if samples have been frozen.

Next steps

The focus for the coming year will be on using HSP70 for early detection of heat stress. Further analysis will look at data across seasons and within herds' to assess the potential application of HSP70 as a tool to monitor heat load in dairy cattle.

Researchers will also investigate if HSP70 is affected by other factors such as mastitis and compare with other available methods used to monitor heat load such as climate data, visual observation and sensors.

Collaborators

The P9b project is a collaboration between Dairy UP researchers at the University of Sydney and NSW DPI and the University of Ruhuna, Sri Lanka.

This project involves a PhD study being undertaken by Rezaul Rakib.

Related work

Other DairyUP projects that are investigating heat load from different angles include P2d: Heat stress and P6: Cow response to climate extremes.

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The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

Additional program supporters, collaborations or partnerships

Charles Sturt University | DairyBio | DataGene | Eagle Direct | Entegra
Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Project Update

P9c: Adding value to dairy waste

July 2024

Getting more from milk

Milk underpins the dairy industry. Getting more from this precious commodity has the potential to increase its value throughout the supply chain.

The Dairy UP team is investigating novel ways to get more value from milk.

There are three elements to this research:

P9a: Producing milk with less lactose

P9b: Milk as an indicator of heat load

P9c: Adding value to dairy waste

This document provides an overview of P9c.

What a waste

In Australia, about 8% (about 710,000 tonnes/year) of total on-farm milk production is discarded as waste. Most of this wastage occurs post farm gate, for example at processing, distribution, food service and consumer stages of the supply chain.

The effect of this wastage is not just economic; it also has an impact on the environment and food security.

Although some efficiency could be gained by reducing total waste, it is also possible to turn what would be wasted into a valuable product. For example, dairy waste can be recycled and repurposed using existing methods such as reverse osmosis, drying, hydrolysis, ultrafiltration, and electrodialysis.

Fermentation

The Dairy UP team is investigating fermentation opportunities to convert dairy wastes into value-added products with an existing commercial market. Fermentation uses microbes such as yeasts to convert dairy wastes into valuable products.

Fermentation is cost-effective, can generate new income streams for farmers and processors as well as reducing waste.

Fermentation can produce a range of compounds, including stockfeed supplements.

Research approach

The project involves four key activities:

- **Review** dairy food wastes in Australia and overseas and identify those with the greatest opportunity for reduction; identify potential products that could be made using microbial fermentation.
  Progress status: in progress.
- **Pilot studies** to develop yeast strains capable of producing valuable compounds from dairy waste.
  Progress status: in progress.
- **Determine the viability** (technical and economic) of achieving products in the quantities required by commercial markets.
  Progress status: in progress.

- **Upscaling the process** for commercial implementation.
  Progress status: not started.

Opportunities

The review identified a wide range of wastage occurring along the production chain. It also identified promising opportunities to use fermentation to reduce wastage.

On farm opportunities
There are opportunities to use fermentation to create value added products from excess colostrum, milk with abnormal composition, and milk from cows treated with antibiotics (e.g. for mastitis).

For example, waste milk could be used to produce microbial protein (also called single-cell protein) as an animal feed or ration additive to improve digestive efficiency.

It may also be possible to use yeast to degrade antibiotics present in waste milk, and then feed the antibiotic-free milk or by-product to calves, thus preventing the development of antibiotic resistance.

Processing/manufacturing

Manufacturing waste makes up 70% of all dairy food waste in the supply chain (Dairy Australia, 2023). The main sources are by-products of milk processing, especially cheese whey, and waste generated during start-ups, shutdowns, equipment cleaning, accidental spills, and wastewater sludge. Additionally, finished products that do not meet specifications or lack sufficient shelf life also contribute to manufacturing waste.

There's potential to use microbial fermentation to convert expired milk, cheese whey and other by-products into bioenergy, enzymes, organic acids, biopolymers and biomass.

The initial lines of investigation are:

- Onfarm: milk from antibiotic treated cows.
- Processing: whey waste.

Yeasts

The Dairy UP team is focussing on fermentation using brewer's or baker's yeast (*Saccharomyces cerevisiae)* which is safe for humans and animals. Yeast is already widely used for fermentation so processes and equipment are readily available. There are also existing paths to market for the end products.

Lactose is a key component of dairy wastes, so the focus is on developing yeast that can grow on lactose.

The team has identified opportunities to use yeast fermentation of lactose in dairy waste to produce:

- Functional milks that are high in specific compounds that could be used as dietary supplements in the cow's diet.
- Enzymes and binders that reduce human and animal health risks such as mycotoxins in stockfeed.
- enzymes and organic acids that improve stock feed quality.
- supplements that optimise cow nutrition (e.g. proteins, amino acids and probiotics).
- Production of ethanol as a biofuel.

Determining the viability

Researchers at Macquarie University's Genome Foundry are using state-of-the-art synthetic biology technology to develop yeast capable of efficiently fermenting lactose to produce valuable compounds.

As a proof-of-concept, yeast strains engineered to produce provitamin A from lactose. Provitamin A is a precursor of vitamin A, has antioxidant properties and is widely used as a dietary supplement for humans and stockfeed.

The next step is to develop yeast that grows directly on milk (rather than lactose which was used in the proof-of-concept study).

Results to date have been encouraging, indicating that it should be possible to refine the approach to fermenting directly from whey.

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Next steps

Once the approach is validated it can be used to develop a range of yeasts capable of transforming dairy waste into a range of valuable products.

Collaborators

The P9c project is a collaboration between Dairy UP, Macquarie University's Australian Genome Foundry and NSW DPI.

Read more

Dairy Australia 2023; Dairy sector food waste action plan.

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Partner organisations

NSW Farmers Growing the best | east AUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

Additional program supporters, collaborations or partnerships

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Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Project Update

P10b: Economics and Risks of Raising Non-Replacement Calves in a Dairy Business

August 2023

This project aimed to analyse the economics and risks of raising non-replacement calves in a dairy business, with the view to selling them as dairy beef.

The market for dairy beef varies across regions, depending on the scale and infrastructure of the local beef supply chain including backgrounders, feedlots and processors.

This means the economics and risks of raising dairy beef tend to be regionally specific making it difficult to offer blanket recommendations.

The benefits and risks are also influenced by the existing dairy farming system and infrastructure for calf rearing. A year round calving system is likely to require less investment in modifying calf rearing systems than a farm operating with a batch calving system. For example, herds with tight batch calving systems (such as in Victoria and Tasmania) may require up to three times the existing calf shed facilities to rear non-replacement calves.

P10 Sustainable pathways for surplus calves

Dairy UP's P10 aimed to develop sustainable options for managing surplus calves born on NSW dairy farms such as male (bobby) calves or females that are not destined for the milking herd. It complemented other Dairy Australia work to address the issue of surplus calves.

Designed to be regionally relevant and applicable to local communities, the Dairy UP project involved two phases:

- Consultation along the entire supply chain and collaborative design of alternative management pathways (Nowra, NSW community)
- An analysis of the economics and risks of raising non-replacement calves in a dairy business.

This document provides an update on the analysis of the economics and risks of raising non-replacement calves in a dairy business.

While P10 is now complete, work on this topic continues through a follow-on project Growing Beef from Dairy which funded jointly by Dairy Australia and MLA.

Case study approach

A case study approach was chosen to provide relevant insights for farmers in the project group. Two case study farms were chosen from the Kempsey/Taree area where some dairy businesses had indicated they were keen to participate.

Farm 1: Year round calving system
Farm 2: Batch calving system.

For each farm, the study compared two scenarios:

- 'Base scenario': all cows joined to conventional dairy semen or dairy bulls with non-replacement calves sold at 3 weeks old.
- Change scenario: Sexed semen used to breed dairy replacements with the rest of the herd joined to beef semen/bulls and beef calves raised to various ages.

Market fluctuations

Market fluctuations during the study period highlighted the risks associated with variations in demand and price for dairy beef. When the project concept was being developed in 2022, demand for dairy beef was strong and project participants were confident they could make a profit from dairy beef. This confidence was challenged over during 2023 when demand (and price paid) for dairy beef weakened significantly.

To get an indication of risks, the analysis looked at best and worst case years and an average.

Key findings

Profitability (net return per head)
Beef market prices were the biggest contributor to variation in net return per head. The feedlot market (and beef market in general) is highly volatile and this has an impact on the prices paid for dairy beef calves.

Net returns varied from $900/head in good years to a loss of $600 in bad years, with about break even on average.

Net returns are also influenced by how long animals are reared before they are sold (from weaning through to 300-600kg).

Risk
Growing out animals to above 450kg can be more profitable but exposes the business to additional downside risk such as land limitations, higher feed costs, seasonal variation (drought, flood) and beef market fluctuations.

Accessing premium markets could reduce some of this risk, but this option varies across regions.

Payback period
The payback period for investment in infrastructure was shorter (1-7 years) for Farm 1 (year round calving) because needed only minor upgrades to accommodate rearing dairy beef calves.

The payback period for Farm 2 (batch calving) could extend to beyond 15 years as it needed more investment in calf rearing infrastructure.

Other considerations
The decision to rear non-replacement calves involves significant non-financial considerations such as animal welfare, ethics and social licence. For some, breaking even on average may be a reasonable balance for these benefits.

Other things to consider include:

- Effort involved in rearing non-replacement calves and the potential distraction from the core business of producing milk.
- Goals of individual farm business owners (specialist dairy farmer versus interest in diversifying)
- Role and availability of a specialist calf rearer.

Next steps

A decision support calculator developed during the project could be tested more widely.

The study authors recommended further analysis of the following situations:

- raising more surplus heifers for export (recognising this is not an option for every Australian dairying region).

- Tight single calving herds where infrastructure investment is greater.

Given dairy beef is an evolving industry, the report recommended updating results as new knowledge and options become available.

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Collaborators

Thank you to the NSW farmers who generously shared their farm and business data for this study.

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Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

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SECTION TWO

Fact Sheets:
P2f Infectious Diseases

Documents

Fact Sheet: Adenoviruses

P2f Infectious Diseases

August 2025

Bovine Adenoviruses (BAdVs)

Adenoviruses are a group of viruses that infect cattle. They commonly cause scours and respiratory diseases, usually in calves.

Antibodies for BAdVs are commonly found in cattle, indicating widespread exposure, most likely as young animals.

Clinical signs and pathogenesis

Clinical signs of BAdV infection vary depending on the form of disease. The respiratory form is characterised by coughing, nasal and ocular discharge, fever, and laboured breathing.

The enteric form presents as diarrhoea, which may range from watery to haemorrhagic, often accompanied by depression, recumbency, and in severe cases, sudden death.

Systemic involvement, particularly associated with BAdV-7, can lead to weak calf syndrome and multi-organ disease.

Transmission

BAdVs spread through faecal-oral and respiratory routes, often shed by animals without symptoms. Stressors like weaning and transport can trigger outbreaks.

Diagnosis

Diagnosis of BAdV infection relies on a combination of histopathology, molecular testing, and serology. Intranuclear inclusion bodies in endothelial cells are characteristic findings on histopathology.

Treatment

There is no specific antiviral treatment for BAdV infections. Management involves supportive care, and treatment of secondary bacterial infections if present.

Key points

- Different types of BAdVs, cause different symptoms ranging from respiratory to scours (enteric) and systemic disease.
- There is no specific antiviral treatment for BAdV infections. Management involves supportive care, and treatment if secondary bacterial infections are present.
- Infections may be triggered by stress and worsened by co-infections such as Bovine Viral Diarrhea Virus (BVDV).
- There is currently no commercially available vaccine in Australia.
- Many cattle have antibodies for BAdVs indicating widespread exposure, most likely as young animals.

Microbial surveillance in dairy cattle

This series of fact sheets has been prepared for cattle vets. It covers a range of microbes that were identified by Dairy UP team in samples collected from cattle on NSW dairy farms in 2023 and 2024. As many of these viruses are new, and knowledge about them is still emerging, we have collated current knowledge as a handy reference.

About Dairy UP

Dairy UP is a research and development program to help NSW farmers unlock the potential of their dairy businesses. Led by the University of Sydney's Dairy Research Foundation, Dairy UP is delivered through NSW DPIRD, Scibus, Dairy Australia, and the University of Sydney.

Control and prevention

Control of BAdV infections relies on good hygiene, strong biosecurity, and reducing stressors such as weaning and mixing calves from different sources.

While a vaccine for BAdV-7 is available in Japan, there are currently no widely used commercial vaccines elsewhere.

Epidemiological notes

BAdV-3 and BAdV-7 are frequently linked to bovine respiratory disease complex (BRDC), while BAdV-10 is associated with fatal hemorrhagic enteritis in calves. Co-infections, particularly with bovine viral diarrhoea virus (BVDV), can worsen clinical outcomes.

Seroprevalence studies indicate high herd-level exposure, with up to 82% of cattle testing positive for BAdV antibodies, although specific virus types are not always identified.

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More info

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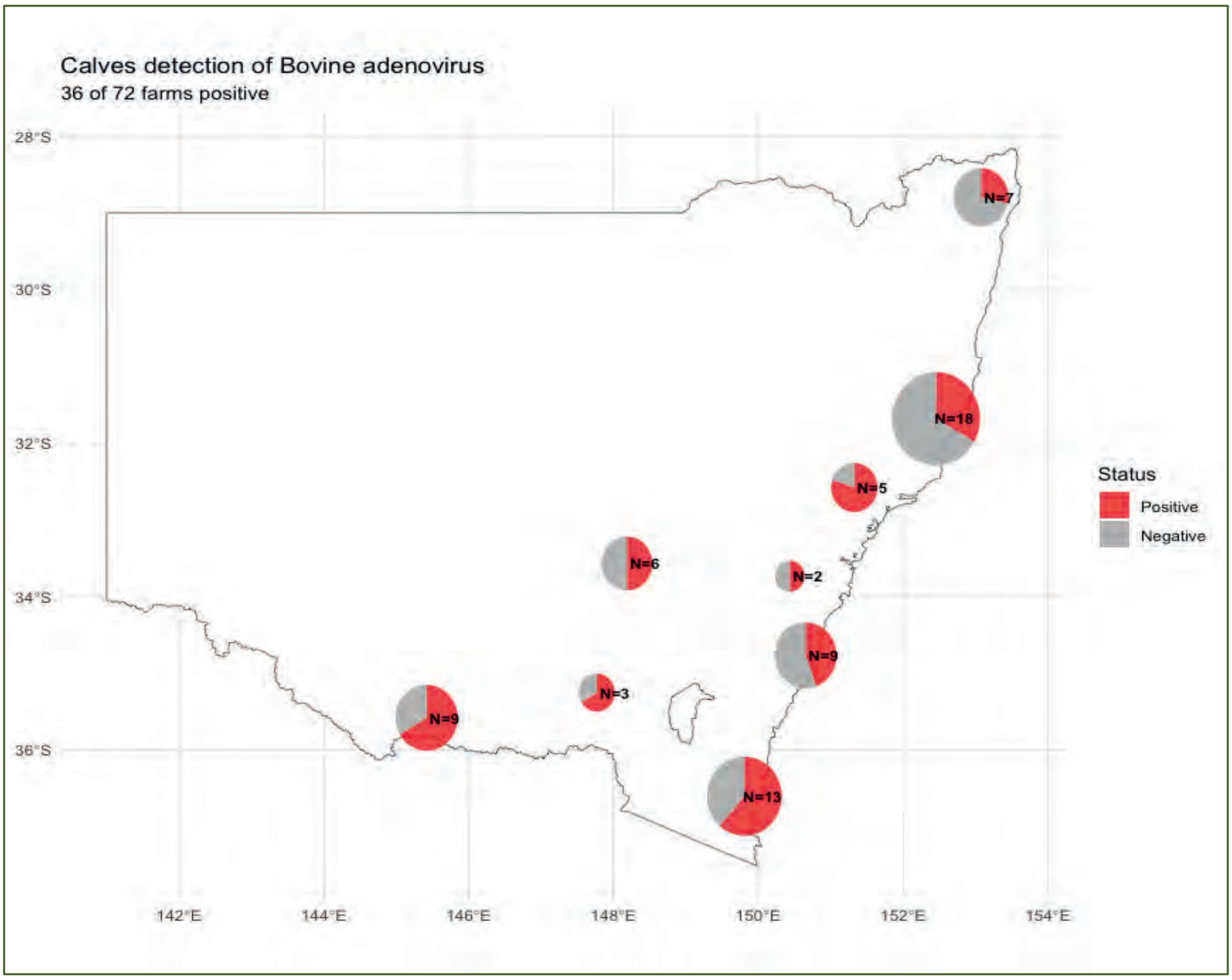

The map shows only BAdV-3, which was the most prevalent. We did not find 7 in samples collected, and only one sample was positive to 6.

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Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | eastAUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

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Thank you to the following organisations for specific funding for this project

McGarvie Smith Institute | Australian Government Australian Research Council | UTS

Fact Sheet: Bovine enteroviruses
P2f Infectious Diseases

August 2025

Bovine enteroviruses (BEVs)

Bovine enteroviruses are viruses that live in the gut of cattle. They are common in cattle all over the world and often found in healthy animals.

Most of the time they don't make the animal sick, but sometimes they cause mild scours or other gut problems in calves.

Transmission

Transmission is usually faecal-oral: infected calves shed the virus in their manure and it is spread to other calves when they swallow manure usually from dirty teats, feeders or bedding. Enterovirus can also spread through aerosols, contaminated soil or water, and vertically (from cow to calf before birth).

These viruses are widely distributed in cattle populations worldwide and are generally considered to have low virulence, often detected in healthy animals.

Bovine enteroviruses (BEVs) are small, non-enveloped, positive-sense RNA viruses in the family Picornaviridae, genus Enterovirus. There are two species: Bovine enterovirus E (subtypes E1–E4) and Bovine enterovirus F (F1–F6). These viruses are widely distributed in cattle populations worldwide and are generally considered to have low virulence, often detected in healthy animals.

Clinical signs and pathogenesis

BEVs are usually asymptomatic but can occasionally cause mild diarrhoea, and rarely respiratory, reproductive (abortion, stillbirth), neurological (encephalitis, ataxia), or cardiovascular signs.

Pathogenesis is unclear; experimental infections show inconsistent disease despite viral replication and localization in the terminal ileum, ileocecal and cecocolonic junctions, spiral colon, lungs, and muscle tissue.

Types of bovine enteroviruses

Bovine enteroviruses (BEVs) are small, non-enveloped, positive-sense RNA viruses in the family Picornaviridae, genus Enterovirus. There are two species: Bovine enterovirus E (subtypes E1–E4) and Bovine enterovirus F (F1–F6).

Key points

- Bovine enteroviruses (BEVs) are common in healthy cattle all over the world.
- They occasionally cause mild scours; rarely respiratory, reproductive, neurological, or cardiac signs.
- It spreads mainly via manure but can also spread in the air, contaminated environment, and from cow to calf before birth.
- There is no specific treatment or vaccine. Control relies on hygiene and supportive care.
- It's not clear how this virus leads to illness. Trials show it can grow in parts of the gut, lungs, and muscle, but development of disease is inconsistent.

Microbial surveillance in dairy cattle

This series of fact sheets has been prepared for cattle vets. It covers a range of microbes that were identified by Dairy UP team in samples collected from cattle on NSW dairy farms in 2023 and 2024. As many of these viruses are new, and knowledge about them is still emerging, we have collated current knowledge as a handy reference.

About Dairy UP

Dairy UP is a research and development program to help NSW farmers unlock the potential of their dairy businesses. Led by the University of Sydney's Dairy Research Foundation, Dairy UP is delivered through NSW DPIRD, Scibus, Dairy Australia, and the University of Sydney.

Laboratory detection

Detection relies on RT-PCR targeting the 5′ UTR. Virus isolation in cell cultures (MDBK, BHK-21, FBK) and electron microscopy can confirm infection. Serological surveys show antibodies in cattle and humans, though no zoonotic disease is confirmed.

Treatment and control

There is no specific antiviral treatment; care is supportive, focusing on hydration and managing secondary infections. Prevention depends on biosecurity, clean feed and water, as no vaccines are currently available.

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More info

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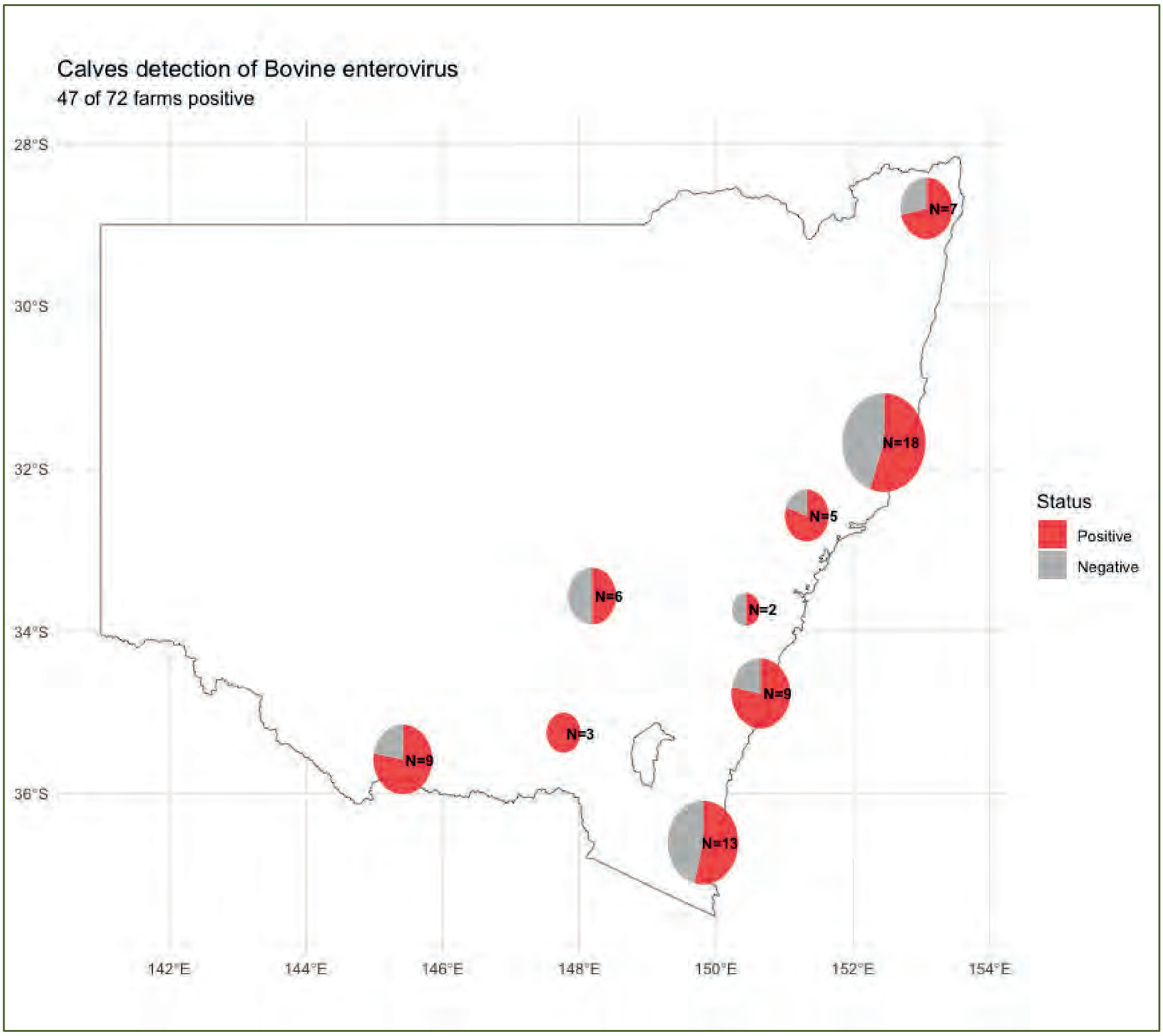

Delivery organisations

Partner organisations

Additional program supporters, collaborations or partnerships

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Macquarie University | NSW EPA | smaXtec | UC Davis | University of Technology Sydney

Thank you to the following organisations for specific funding for this project

Fact Sheet: Bovine Giardiasis

P2f Infectious Diseases

August 2025

Bovine Giardiasis

Giardiasis is gut illness that affects calves (especially under 8 weeks), lambs, and humans. Infected calves may show no symptoms, or have mild scours, reduced weight gains or ill thrift.

It is caused by a parasite (protozoa) that infects the small intestine - *Giardia duodenalis* (also known as *G. intestinalis* or *G. lamblia*).

It is spread between animals as the parasite passes out in manure as cysts, which survive in the environment and infect other cattle when swallowed.

Species affected

Calves and lambs are the most likely to be affected by Giardiasis.

Severity

The severity of symptoms varies by age and strain (assemblages A, B, E). Studies show negative effects on growth. Treatment reducing cyst shedding improves weight gain in calves.

Transmission

The parasite is spread via the faecal–oral route through ingestion of infective cysts. Transmission occurs through contaminated water, surfaces, and direct contact with infected animals.

Laboratory detection

Common diagnostic tools include coproantigen ELISA, microscopy, direct immunofluorescence, and PCR.

Treatment and control

Treatment with fenbendazole is effective. Control relies on hygiene: cleaning and disinfecting pens, removing manure, allowing empty periods, and minimizing contact with shedding animals. Coccidiostats are not effective.

Key points

- Bovine Giardiasis is a protozoan parasite that infects the small intestine of calves, lambs, and humans.
- Symptoms are often mild but it can cause scours, poor growth, and ill-thrift.
- It is spread via manure; cysts can persist in the environment.
- Diagnosis is by ELISA, microscopy, immunofluorescence, or PCR.
- Treat with fenbendazole; control through hygiene and biosecurity.
- It is unclear whether *G. duodenalis* can be transmitted from cattle to humans; more research is needed on transmission and prevalence.

Microbial surveillance in dairy cattle

This series of fact sheets has been prepared for cattle vets. It covers a range of microbes that were identified by Dairy UP team in samples collected from cattle on NSW dairy farms in 2023 and 2024. As many of these viruses are new, and knowledge about them is still emerging, we have collated current knowledge as a handy reference.

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Zoonotic potential

G. duodenalis is an emerging zoonotic pathogen. Assemblage A poses the greatest risk for human infection.

Research gaps

Unclear clinical impact in cattle, limited data on assemblage distribution, zoonotic transmission dynamics, and molecular diversity. More studies are needed on epidemiology and risk factors.

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More info

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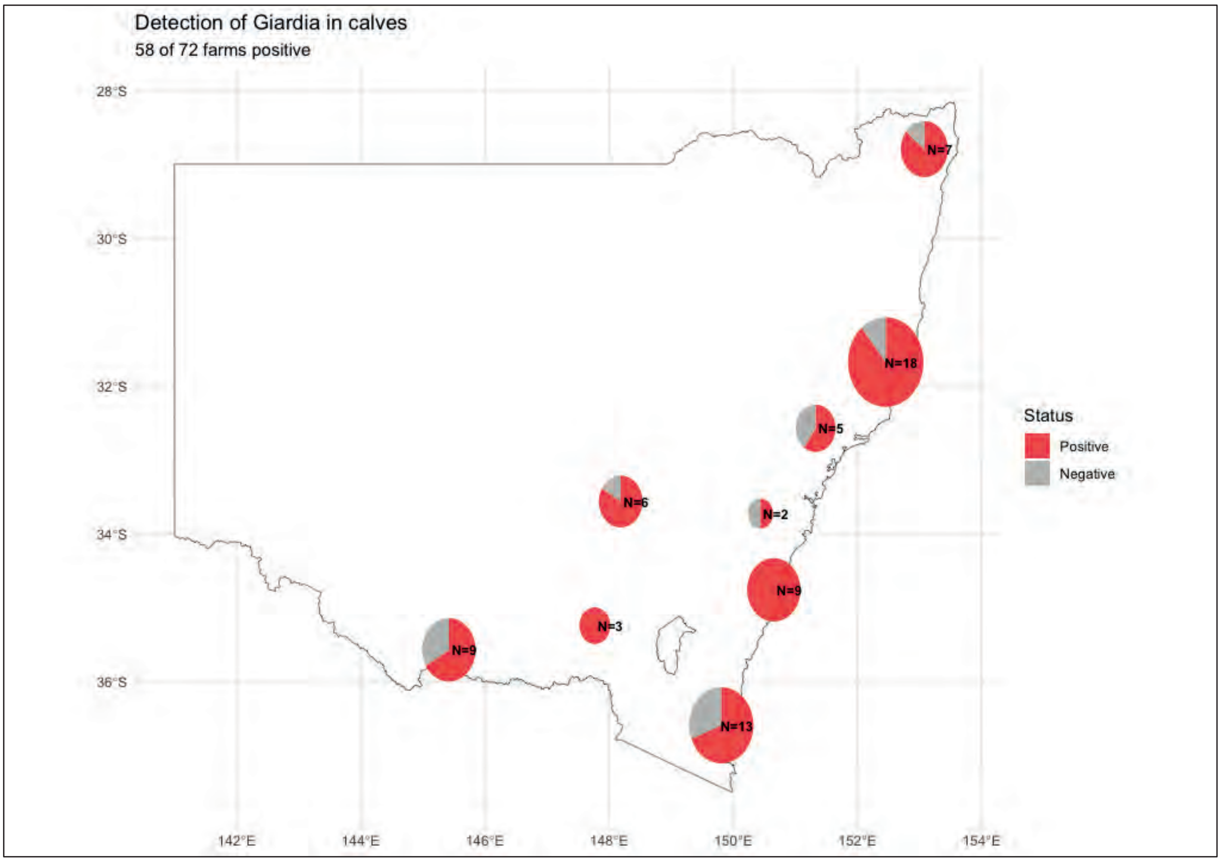

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Delivery organisations

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Fact Sheet: Bovine Hunnivirus P2f Infectious Diseases

August 2025

Bovine Hunnivirus

Bovine hunnivirus (BHuV) has been detected in cattle in multiple countries, but its role in causing disease remains unclear. It was detected on all farms in our study.

There is no consistent pattern of clinical symptoms – it has been detected in calves with scours as well as in healthy animals. There are no reports of respiratory or systemic illness in cattle. It is thought to be spread via the faecal-oral route.

Other species

Laboratory studies show that a related hunnivirus in buffalo can damage kidney and intestinal cell lines after 72 hours, but no tissue damage has been observed in animals. In other species, hunniviruses have been linked to gastrointestinal disease and occasionally to heart, liver, or brain issues. The tissues targeted by BHuV in cattle remain unknown, but in buffalo, the virus may suppress immune responses by blocking interferon production.

Transmission

Transmission is likely faecal–oral, though this has not been experimentally confirmed.

Laboratory detection

Routine testing for BHuV is not widely available. Detection primarily relies on RT-PCR to identify viral RNA in faeces. Virus isolation has been achieved in Madin-Darby bovine kidney (MDBK) cells, and ELISA has been used in seroprevalence studies, revealing low antibody levels in cattle. No standardized diagnostic protocols or culture methods are currently in place.

Notes

Bovine hunnivirus (BHuV) is a non-enveloped, single-stranded RNA virus in the family Picornaviridae (genus Hunnivirus).

The causal role of BHuV in disease has not been established. Although it is frequently detected in diarrheic calves, it is also found in healthy animals, and no definitive link to illness has been proven. Further research is needed to clarify its pathogenic significance.

Key points

- Bovine hunnivirus (BHuV) is a picornavirus detected in cattle worldwide.
- Its role in causing disease is unclear. It is found in calves with and without diarrhoea.
- There is currently no evidence it causes respiratory or systemic disease in cattle.
- More research is needed to find out which tissues the virus affects and how this links to disease.

Microbial surveillance in dairy cattle

This series of fact sheets has been prepared for cattle vets. It covers a range of microbes that were identified by Dairy UP team in samples collected from cattle on NSW dairy farms in 2023 and 2024. As many of these viruses are new, and knowledge about them is still emerging, we have collated current knowledge as a handy reference.

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Fact Sheet: Bovine Kobuvirus

P2f Infectious Diseases

August 2025

Bovine Kobuvirus (BKV)

Bovine Kobuvirus (BKV) mainly affects calves, especially newborns and 1–2 months old. It is detected in both healthy and scouring cattle worldwide.

There is no vaccine or antiviral. Prevention relies on biosecurity and hygiene. Treatment involves supportive care for scours (fluids, electrolytes).

Clinical signs

The main reported symptom of BKV infection is diarrhoea. Its role remains unclear due to frequent co-infections and detection in healthy animals. One study linked BKV to necrotizing enteritis in calves that tested negative for other pathogens.

Transmission

Transmission is believed to occur via the faecal-oral route which is typical of gut enteric viruses. The high prevalence suggests widespread exposure in cattle populations.

Control and prevention

There is no specific antiviral treatment for BKV. Supportive care for diarrhoea (fluids, electrolytes) is standard.

No vaccine is available for BKV. Prevention relies on strict biosecurity and good hygiene practices to minimize exposure.

Bovine Kobuvirus (BKV)

Bovine Kobuvirus (BKV) is a non-enveloped, single-stranded, positive-sense RNA virus in the Picornaviridae family, Kobuvirus genus (species Aichivirus B). The name "kobu" is derived from the Japanese word for "bump," reflecting its characteristic appearance under electron microscopy.

Key points

- Diarrhoea is the main reported symptom, but BKV is often found in healthy animals.
- Its role in disease is unclear as BKD is frequently co-detected with other gut pathogens.
- No vaccine is available. Prevention relies on biosecurity and hygiene.
- It is found globally in cattle and small ruminants, suggesting widespread exposure.

Microbial surveillance in dairy cattle

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Laboratory detection

BKV is diagnosed mainly by RT-PCR or real-time RT-PCR targeting the 3D gene. Virus isolation is possible in Vero cells, showing cytopathic effects. It can also be detected in faecal samples using metagenomic sequencing and specific PCR assays.

Epidemiology and research gaps

In some outbreaks, BKV has been detected more frequently than traditional enteric viruses. Its pathogenic role in calves remains uncertain. Only one study has linked BKV to histopathologic changes consistent with primary viral enteritis in pathogen-negative calves. In goats, experimental inoculation with a related kobuvirus (Aichivirus C) confirmed its ability to cause diarrhoea.

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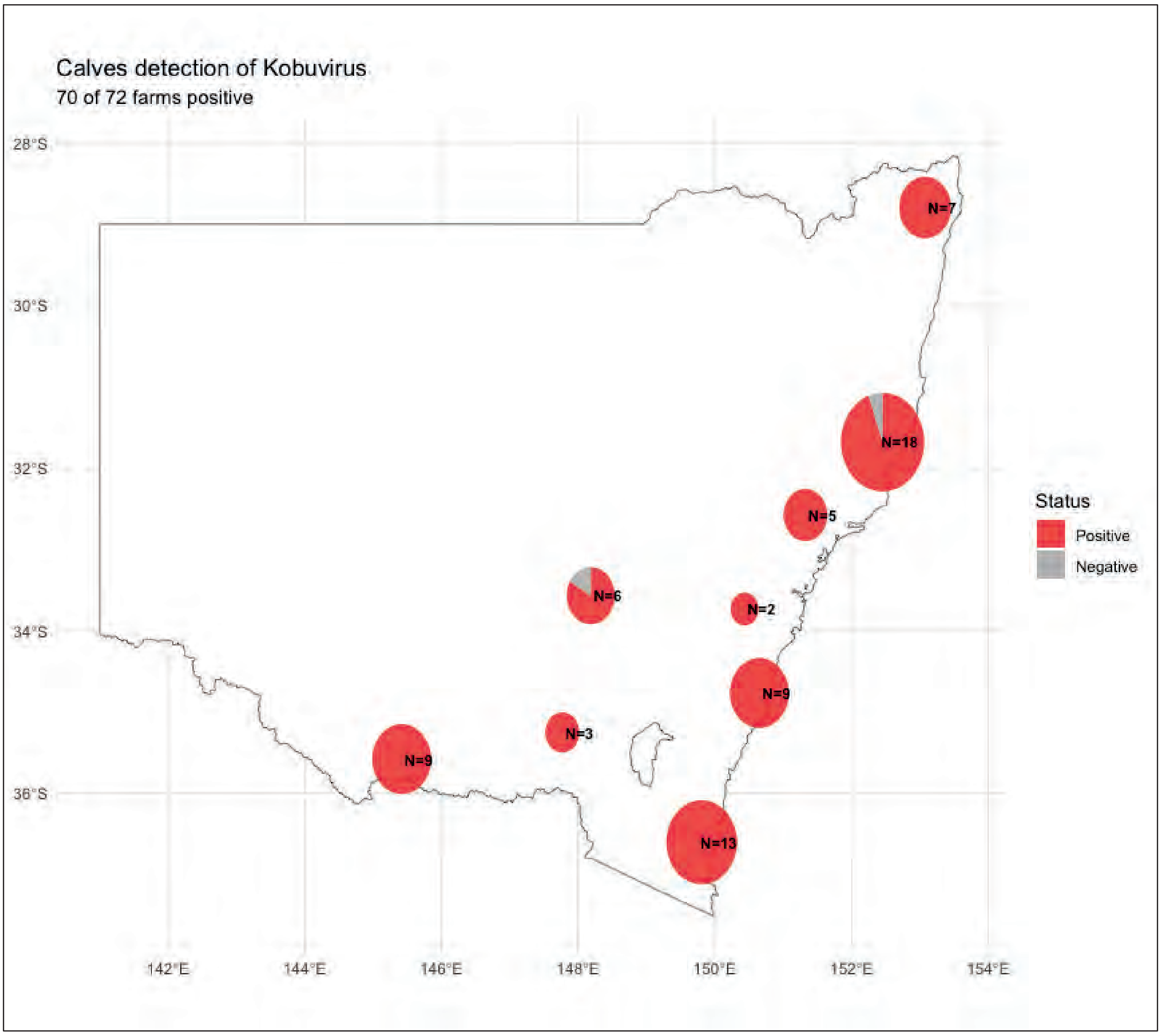

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Fact Sheet: Bovine Nebovirus

P2f Infectious Diseases

August 2025

Bovine Nebovirus (BoNeV)

Bovine nebovirus causes scours in calves with varying severity, often accompanied by loss of appetite and lethargy. No vaccines or specific treatments exist. Control relies on hygiene and supportive care.

Transmission

BoNeV spreads mainly through direct contact between animals and the faecal-oral route: infected calves – even those without symptoms shed the virus in their manure for extended periods. It is spread to other calves when they come in contact with from contaminated feed, water and equipment.

Clinical signs and pathogenesis

Bovine nebovirus infections mainly affect young calves, causing diarrhoea that can range from mild to acute, along with loss of appetite, lethargy, and temporary weight loss. In some cases, malabsorption occurs, meaning calves may not properly digest certain nutrients, which can slow growth and affect overall condition.

Treatment and control

There are no commercial vaccines or specific treatments for BoNeV. Management focuses on supportive fluid therapy for diarrhoea and strict hygiene measures, such as cleaning pens and separating calves, to reduce transmission.

Post-mortem, pathological findings

Bovine nebovirus primarily affects the upper small intestine (duodenum and jejunum), causing villus atrophy, crypt hyperplasia, and mucosal inflammation. Viral replication occurs in the intestinal epithelial cells. These changes impair nutrient absorption, leading to diarrhoea and poor growth. Rarely, severe cases may show necrotizing hepatitis and intestinal haemorrhages.

Key points

- Bovine nebovirus (BoNeV) is an enteric calicivirus affecting mainly young calves.
- It causes scours of varying severity, often with loss of appetite and lethargy; malabsorption may occur.
- The virus targets the upper small intestine, causing villus atrophy and crypt hyperplasia.
- It is spreads via the faecal-oral route; asymptomatic calves can shed the virus.
- No vaccines or specific treatments exist; control relies on hygiene and supportive care.
- Research is limited due to lack of cell culture systems and diagnostic tools, leaving its full pathogenic role unclear.

Microbial surveillance in dairy cattle

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Laboratory detection

RT-PCR is the primary tool for detecting BoNeV. Other methods include electron microscopy, immunofluorescence, and antigen capture ELISA, though commercial diagnostic kits are not widely available.

Genetics

Bovine nebovirus (BoNeV) is an enteric virus belonging to the genus *Nebovirus* in the family *Caliciviridae.* It is genetically distinct from bovine

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noroviruses but shares similar structural features typical of caliciviruses. BoNeV is a recognized enteric pathogen in cattle, especially young calves, and has been linked to diarrhoea outbreaks. It may act alone or in combination with other gut pathogens.

Bovine nebovirus (BoNeV) includes two main genotypes: the Nebraska (NB) strain from the USA and the Newbury1 strain from the UK. A related virus, Kırklareli virus, has been detected in Turkey and is genetically closest to neboviruses, though it is not officially classified as one.

Research challenges

Its exact pathogenic role is unclear, it could be a primary pathogen, co-infective agent, or commensal. No cell culture system, reverse genetics tools, or animal models exist for detailed study. Limited diagnostics hinder epidemiological understanding, and its overall impact on calf health and productivity needs further investigation.

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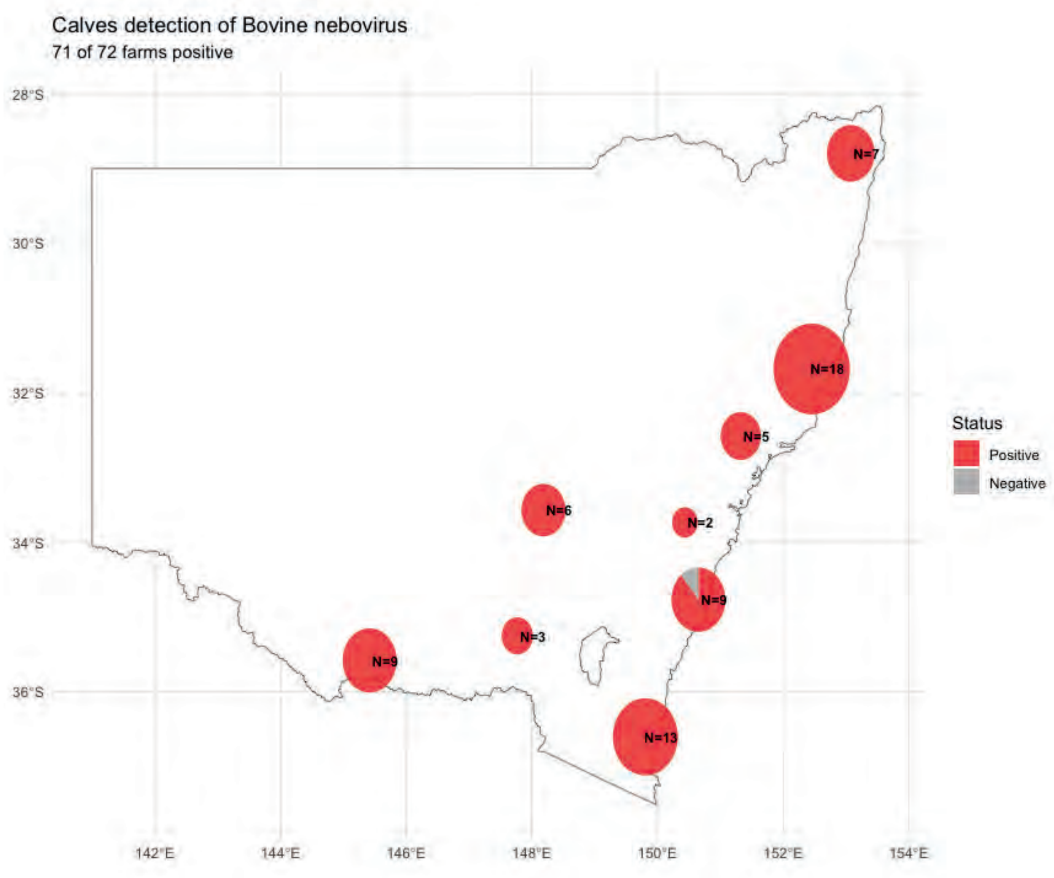

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Fact Sheet: Bovine Norovirus
P2f Infectious Diseases

August 2025

Bovine Norovirus (BoNoV)
Bovine noroviruses (BoNoVs) are found worldwide and mainly affect newborn and pre-weaned calves. Infections are uncommon in calves older than six months and disease is rarely seen in adult cattle. It was found on all farms sampled in our study.

Transmission
Bovine noroviruses spread mainly through the faecal-oral route, meaning calves become infected by ingesting the virus from contaminated manure or surfaces. Healthy-looking calves can carry and shed the virus, so infection can occur even without obvious sick animals in the group.

Treatment and control
There is no specific antiviral treatment for bovine norovirus. Management focuses on supportive care, including oral rehydration and good nutrition. Preventive measures rely on hygiene—keeping calving pens clean, minimizing faecal contamination, and isolating sick calves.

Vaccines are not yet available, but research is exploring virus-like particle (VLP) vaccines for future use.

Genetics
Bovine caliciviruses are part of the *Caliciviridae* family. Different strains can vary in how sick they make calves, with some causing worse symptoms than others. BoNoV belongs to genogroup GIII, which has four genotypes. The most important two are:
• **GIII.1 (Jena virus):** can cause more severe diarrhoea in calves under experimental conditions.
• **GIII.2 (Newbury virus):** most common in the field, usually linked to mild or moderate diarrhoea.

Key points
- Bovine noroviruses (BoNoVs) mainly affect newborn and pre-weaned calves.
- Clinical signs range from mild to severe watery diarrhoea, depending on the strain (GIII.1 more severe, GIII.2 more common but milder).
- Transmission is faecal-oral, and healthy calves can shed the virus without showing symptoms.
- No specific treatment or vaccine exists; control relies on hygiene and supportive care.
- Research is limited due to difficulties growing the virus in cell culture, slowing vaccine development.

Microbial surveillance in dairy cattle
This series of fact sheets has been prepared for cattle vets. It covers a range of microbes that were identified by Dairy UP team in samples collected from cattle on NSW dairy farms in 2023 and 2024. As many of these viruses are new, and knowledge about them is still emerging, we have collated current knowledge as a handy reference.

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Clinical signs and pathogenesis
The severity depends on the strain. GIII.1 (Jena virus) can trigger sudden, severe watery diarrhoea within 14–16 hours, lasting about three days.

GIII.2 (Newbury virus) is more common in the field and usually causes milder signs like soft stools, reduced appetite, and tiredness.

The virus mainly targets the small intestine, especially the jejunum and ileum. It causes villus atrophy (loss of absorptive structures) and crypt hyperplasia (increased cell growth in intestinal glands), which reduce nutrient absorption and lead to diarrhoea and poor growth in calves.

Laboratory detection

Bovine norovirus is most reliably detected using RT-PCR or qRT-PCR. ELISA tests for antigens or antibodies can be used for research or herd-level screening but are less sensitive than PCR.

Research challenges

Because they don't grow well in standard lab cell cultures, studying their role in disease has been challenging.

Historically, detection relied on electron microscopy or infecting animals. While recent advances have enabled human norovirus growth in special cell systems, these methods don't work for bovine strains yet. This limitation slows progress in understanding the virus and developing vaccines.

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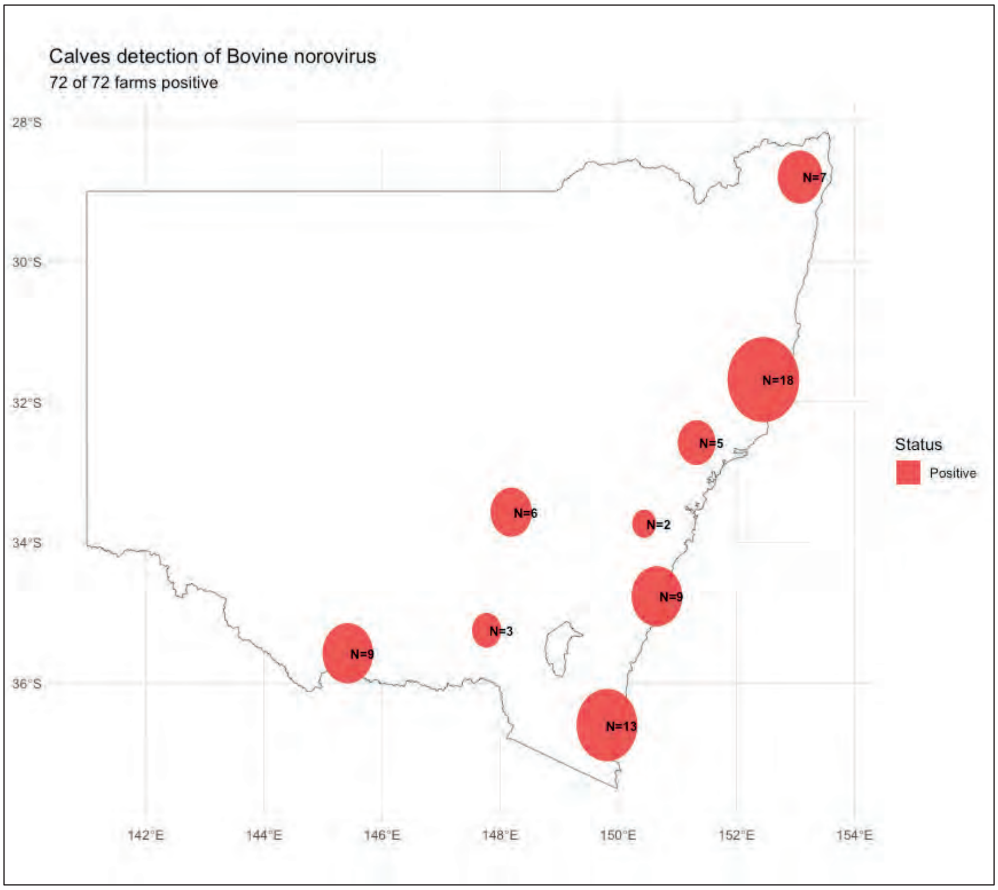

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Fact Sheet: Bovine Parechovirus
P2f Infectious Diseases

August 2025

Bovine Parechovirus

Bovine parechovirus (BoParV) was discovered fairly recently and its role in disease is currently not clear. Knowledge about its biology and clinical relevance remains limited.

Since its discovery in 2018, BoParV has been detected in both calves and adult cattle. It's been found healthy animals and those with scours, suggesting possible subclinical infections.

The modes of transmission have not been studied but it has been detected in manure so probably spreads via the faecal oral route: infected animals shed the virus in their manure and spreads to other calves when they swallow material from contanimated manure and surfaces.

Current knowledge

Clinical signs, pathogenicity & in vitro evidence

BoParV is an unclassified virus within the genus Parechovirus (family Picornaviridae), a non-enveloped, positive-sense RNA virus. It was first identified through metagenomic sequencing.

No definitive clinical syndrome has been linked to BoParV, though it is often found in faecal samples from diarrheic cattle. Experimental infections have not been performed, and no histopathology data exist. The virus has been isolated from bovine faeces in MA104 and Marc-145 cells, producing cytopathic effects within 2–3 days after inoculation.

Its pathogenic role remains unclear, and it is frequently detected alongside other enteric pathogens.

Laboratory detection

No routine diagnostic tests or serology are available. It can be detected with real-time RT-PCR targeting parechovirus RNA and virus isolation in MA104 cells. Both of these tools are used only in research settings.

Notes

The clinical significance of BoParV is uncertain. More research is needed to clarify its pathogenicity, tissue tropism, and epidemiology.

Key points

- Bovine parechovirus (BoParV) is a picornavirus first detected in 2018.
- Its role in disease is unclear.
- BoParV is found in scouring and healthy cattle; no consistent clinical signs confirmed.
- Isolated in MA104 and Marc-145 cells; causes cytopathic effect in vitro.
- Likely faecal–oral transmission; no experimental infections or histopathology data.
- Diagnosis by RT-PCR or virus isolation (research only); no routine tests available.
- No vaccines or treatments; control relies on hygiene and biosecurity.
- Further research needed on pathogenicity, tissue tropism, and prevalence.

Microbial surveillance in dairy cattle

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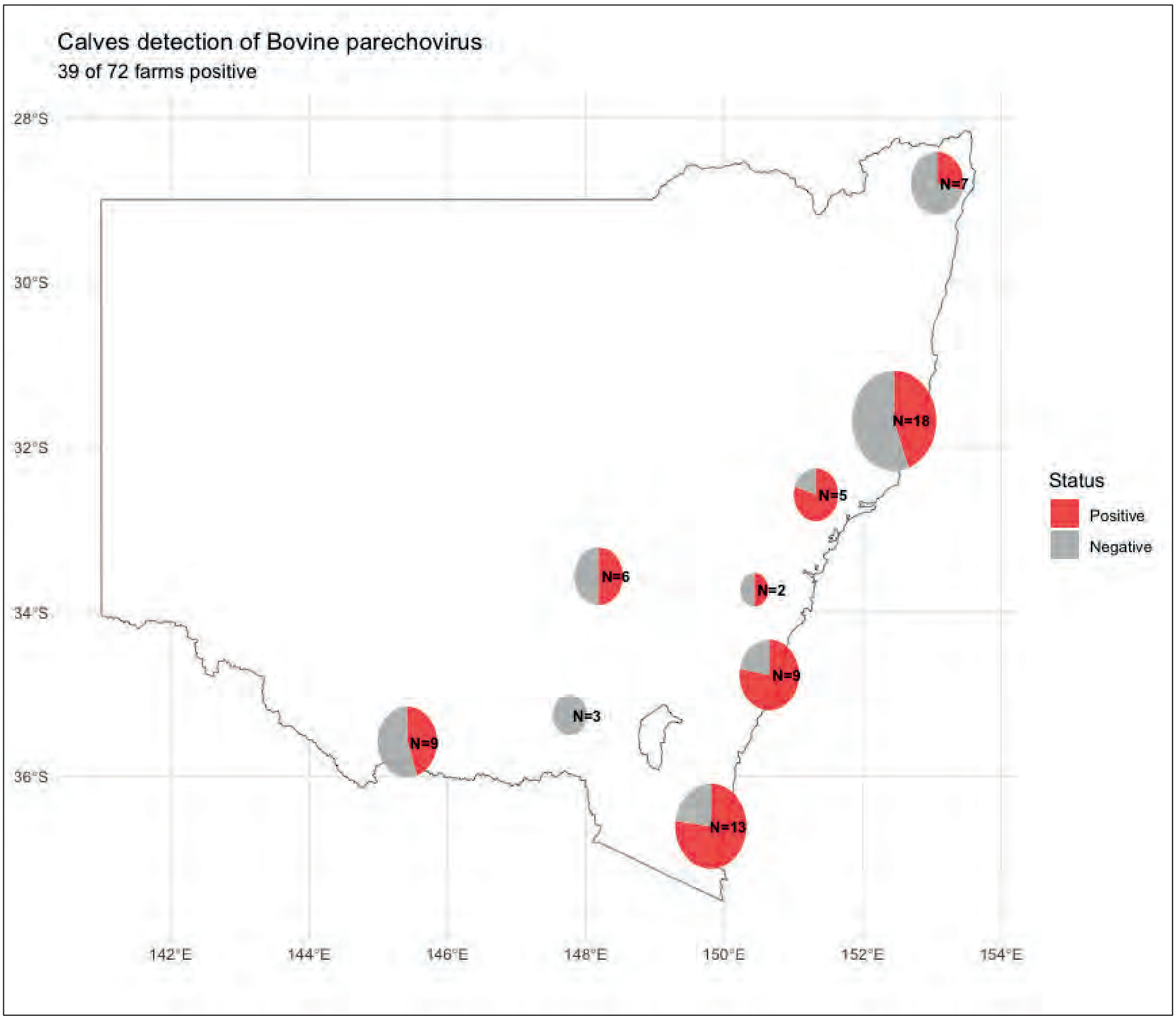

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Fact Sheet: Bovine Picornaviruses

P2f Infectious Diseases

August 2025

Bovine Picornaviruses

Boosepivirus and Bopivirus are recently identified members of the *Picornaviridae* family.

They have been detected in young livestock, mainly young cattle under 12 months old.

These viruses are most often found in manure faecal samples but their role in causing disease is unclear.

Bopivirus has also been reported in sheep and goats, though its clinical significance in these species is unknown.

Current knowledge

These viruses have been found in both scouring healthy calves, suggesting possible subclinical infections. No consistent clinical signs, experimental infections, or tissue studies have been reported, and their pathogenic potential is unknown. Virus isolation in cell culture has not been documented.

Laboratory detection

Detection relies on RT-PCR or metagenomic sequencing in research settings. No routine diagnostic tests, serology, or culture methods are currently available in veterinary practice.

Notes

The presence of these viruses in diarrheic calves may be incidental. Further research is needed to determine their relevance to cattle health.

Key points

- Boosepivirus and Bopivirus are picornaviruses detected in young cattle;
- Their role in disease is uncertain.
- They are found in scouring and healthy calves; no consistent clinical signs confirmed.
- There have been no experimental infections, histopathology, or cell culture isolation reported.
- Diagnosis is not routinely available in labs. It can be detected with RT-PCR or metagenomics.
- The clinical significance of these viruses remains unclear; more research is needed.

Microbial surveillance in dairy cattle

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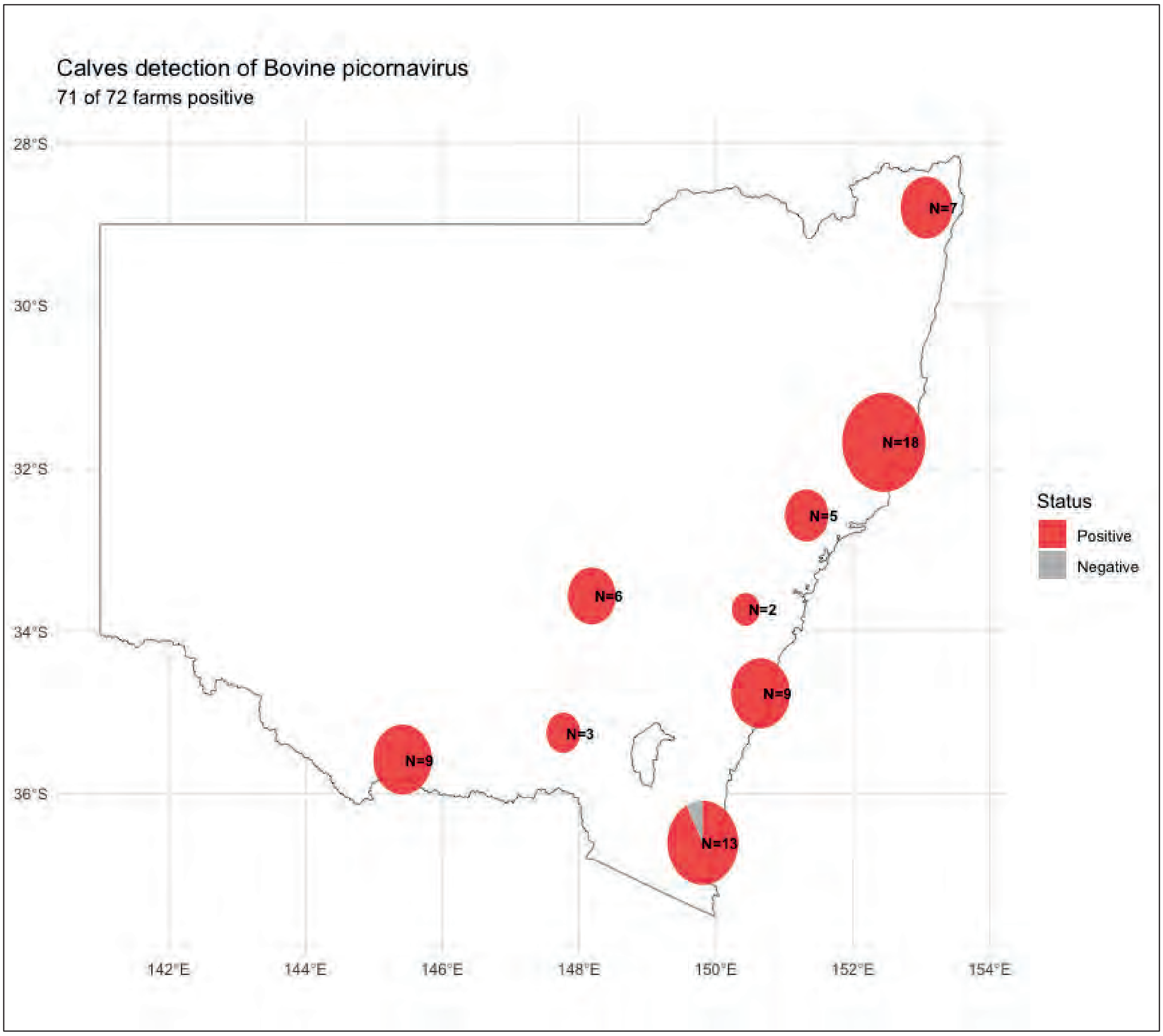

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Fact Sheet: Bovine Rhinitis A & B

P2f Infectious Diseases

August 2025

Key points

- BARAV and BRBV are RNA viruses from the *Aphthovirus* genus, *Picornaviridae* family.
- Both contribute to the Bovine Respiratory Disease Complex (BRDC), often in co-infection with other respiratory pathogens.
- Though typically causing mild signs, they can act as initiators or co-factors in respiratory disease outbreaks.

Microbial surveillance in dairy cattle

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Bovine Rhinitis A & B viruses

Bovine rhinitis A and B viruses (BRAV, BRBV) contribute to Bovine Respiratory Disease (BRD). They mostly infect cattle, with limited evidence suggesting potential spillover to sheep.

Infections are usually mild but may contribute to outbreaks. No vaccines are currently available.

Transmission

BRAV and BRBV are likely transmitted via aerosol and direct contact, with spread facilitated by stress, crowding, and co-infections, conditions commonly encountered in feedlot environments.

Treatment

There is no specific antiviral therapy available for BRAV or BRBV infections. Management involves supportive care and addressing co-infections.

Control and prevention

Currently, no vaccines are available for BRAV or BRBV. Control relies on broader BRD management strategies, including minimizing transport stress, improving ventilation, quarantining new arrivals, and controlling other respiratory pathogens.

Clinical signs and pathogenesis

Clinical signs are generally mild or subclinical, including nasal discharge, coughing, sneezing, and occasionally fever or upper airway irritation.

However, BRAV and BRBV may act as primary initiators or co-factors in respiratory outbreaks, often in co-infection with other pathogens. Both viruses infect epithelial cells of the nasal cavity and trachea, with BRBV frequently localized to these tissues in experimental and natural infections. Histopathological findings are minimal, with viral RNA detected in mucosal tissues. Both viruses may impair mucosal immunity, facilitating secondary infections by other BRD pathogens.

Diagnosis

Bovine rhinitis A and B viruses, members of the *Aphthovirus* genus (*Picornaviridae*).

BRAV and BRBV are not available in routine diagnostic panels, yet they are increasingly recognized as contributors to the BRD.

They are primarily diagnosed using RT-PCR, which offers sensitive and specific detection. Viral isolation and sequencing are valuable for monitoring genetic diversity and tracking viral evolution. Although genetically distinct, both viruses exhibit regional variation and recombination, underscoring the importance of molecular surveillance in outbreak investigations.

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More info

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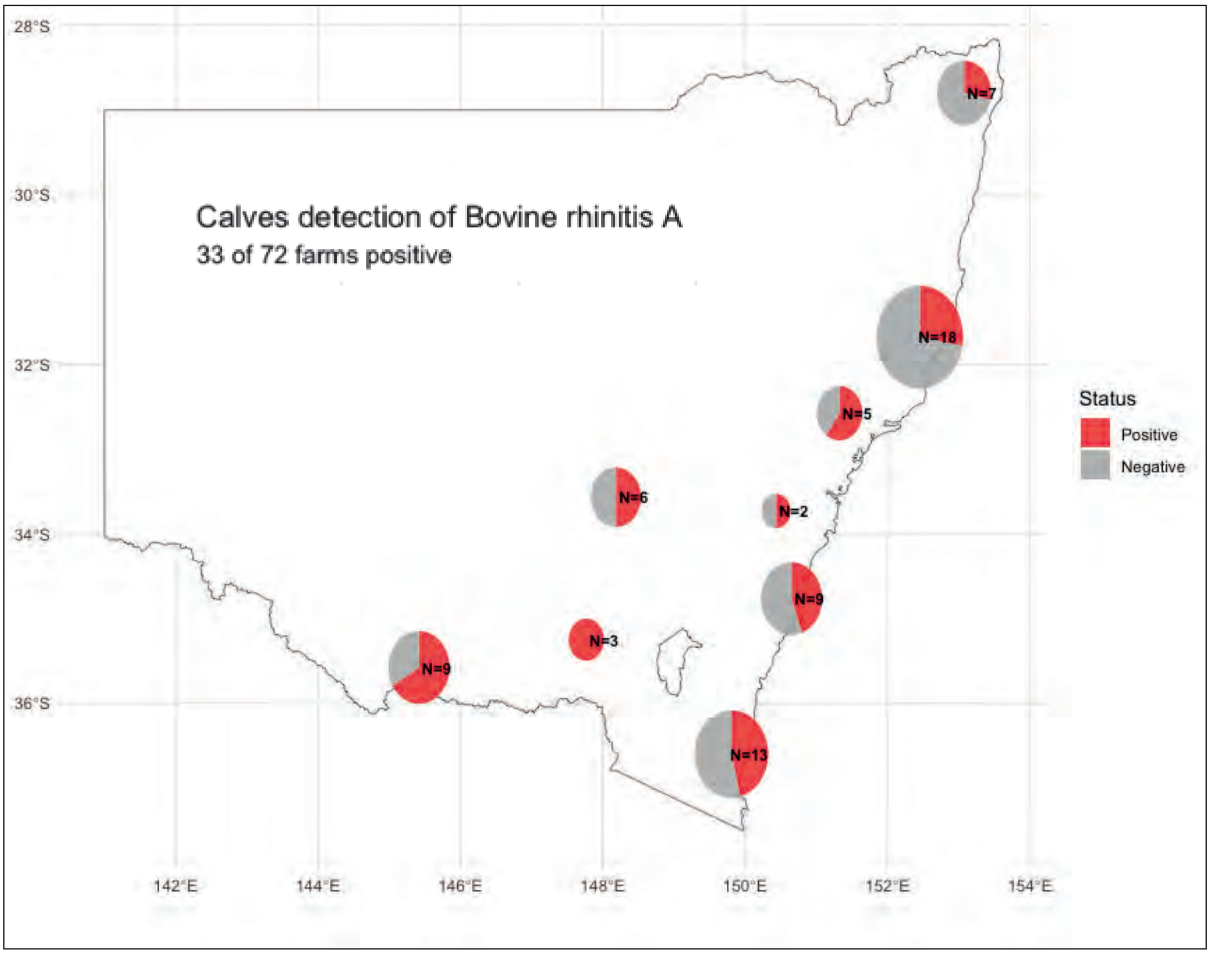

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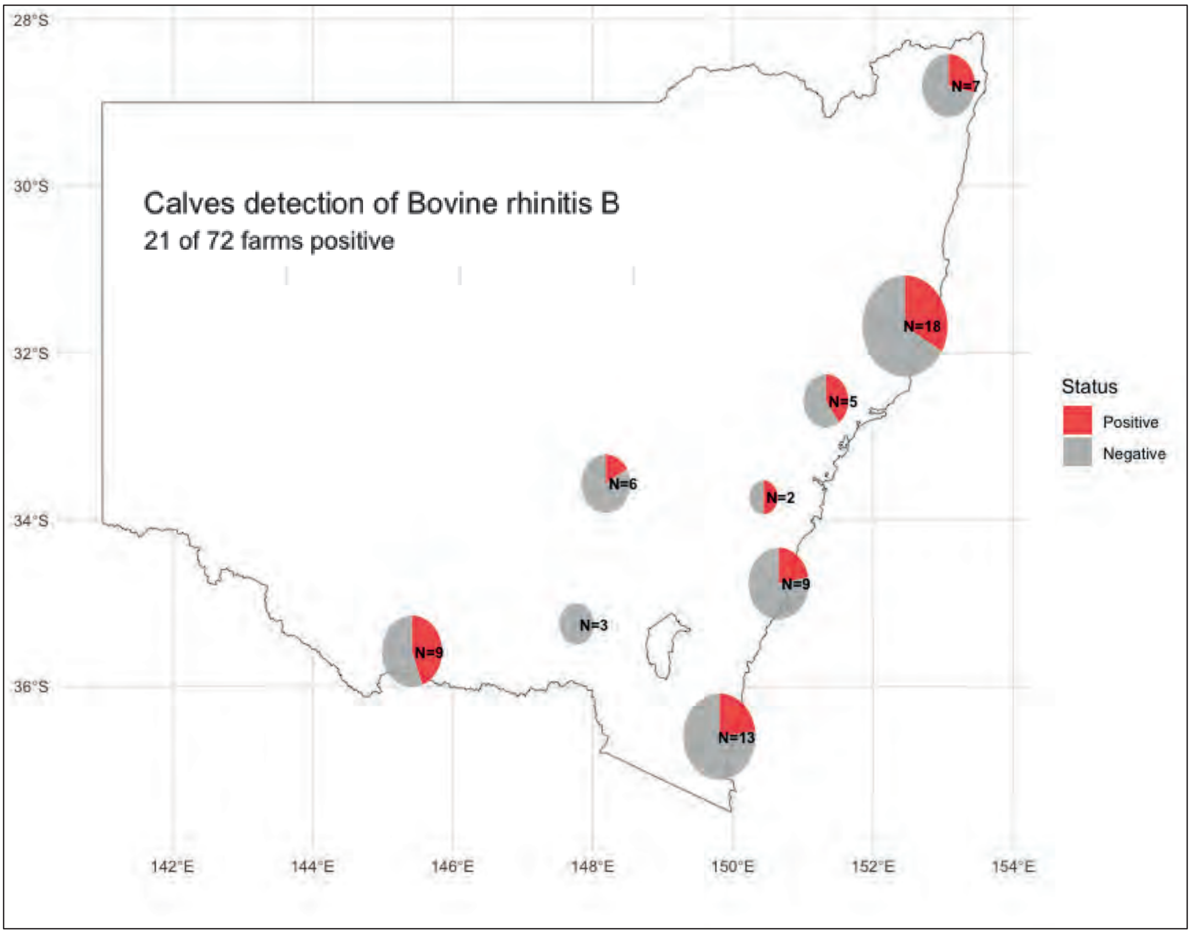

Delivery organisations

The University of Sydney Dairy Research Foundation | NSW Department of Primary Industries | Scibus | Dairy Australia

Partner organisations

NSW Farmers Growing the best | east AUSmilk | Dairy NSW | Dairy Australia | AFMH | Leppington Pastoral Company Pty Ltd | NSW Local Land Services | Norco

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Fact Sheet: Bovine Torovirus
P2f Infectious Diseases

August 2025

Bovine Torovirus (Breda virus)

Bovine Torovirus (BoTV) – also known as Breda virus – is recognised as a cause of scours in young calves and may also affect the respiratory tract.

It mostly affects calves 1-6 weeks old but there is widespread antibody presence in adult cattle.

This virus is widespread in cattle herds globally.

Clinical signs

The most common signs are diarrhoea, dehydration and weakness, especially in calves under 3 weeks old.

The virus has also been found in nasal secretions of calves with respiratory symptoms.

Transmission

Calves catch BoTV from other infected calves, via faeces, and possibly through the fluids in the nose and mouth.

Treatment

There is no specific antiviral available for Breda virus. Follow standard care practices for calf scours: hydration and supportive therapy.

Control and prevention

As there isn't a vaccine available, control and prevention relies on hygiene, colostrum intake, and minimising stress in calves.

Diagnosis

Bovine Torovirus (BoTV) is an RNA virus in the *Coronaviridae* family. Samples from faecal or nasal swabs can be used for RT-PCR and ELISA tests.

The virus is hard to culture; only one strain (Aichi/2004) has been isolated in lab.

Key points

- BoTV (Breda virus) is detected in both gut and respiratory tracts.
- It is commonly found with other gut and respiratory bugs but can act alone.
- The fact that many adult cattle have antibodies suggests they were exposed to the virus, likely when they were young.
- There is no vaccine available.
- BoTV is still under investigation, with ongoing studies to clarify its full impact on calf health.

Microbial surveillance in dairy cattle

This series of fact sheets has been prepared for cattle vets. It covers a range of microbes that were identified by Dairy UP team in samples collected from cattle on NSW dairy farms in 2023 and 2024. As many of these viruses are new, and knowledge about them is still emerging, we have collated current knowledge as a handy reference.

About Dairy UP

Dairy UP is a research and development program to help NSW farmers unlock the potential of their dairy businesses. Led by the University of Sydney's Dairy Research Foundation, Dairy UP is delivered through NSW DPIRD, Scibus, Dairy Australia, and the University of Sydney.

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More info

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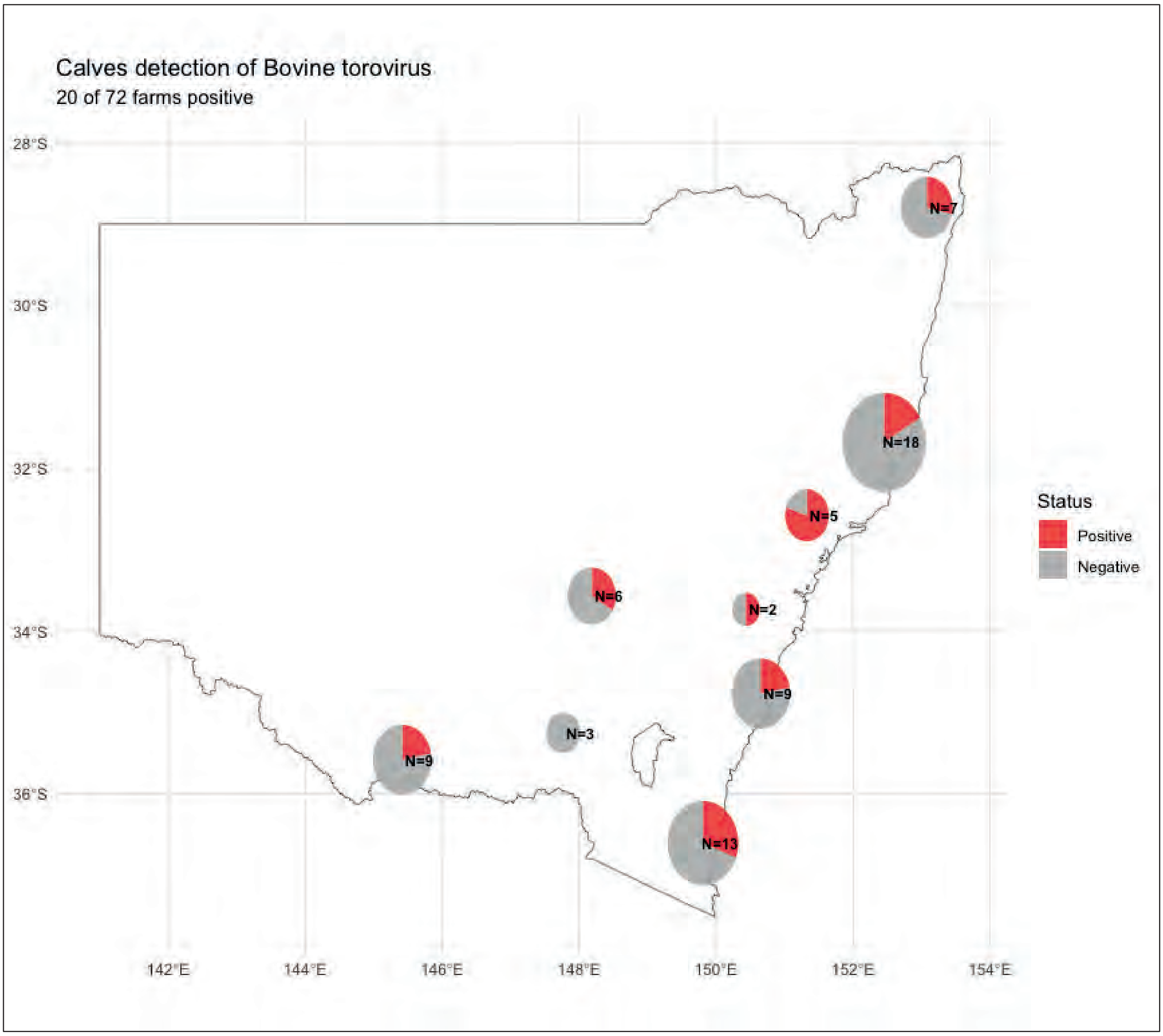

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SECTION THREE

Scientific Reports:

(first page only)

Documents

P1a: Accounting for minimum data required to train a machine learning model to accurately monitor Australian dairy pastures using remote sensing

P1d: Potential applications of a low-cost gas sensor to monitor enteric methane emission from ruminant animals

P1d: Dietary concentrate supplementation increases milk production and reduces predicted greenhouse gas emission intensity in pasture-based commercial dairy farms

P2a: Holstein dairy cows lose body condition score and gain body weight with increasing parity in both pasture-based and total mixed ration herds

P2a: Associations of parity with health disorders and blood metabolite concentrations in Holstein cows in different production systems

P2a: Associations among body condition score, body weight and serum biochemistry in dairy cows

P2a: A large multisite lipidomic investigation of parity and aging in dairy cows

P2a: Increased parity is negatively associated with survival and reproduction in different production systems

P2a: Confinement and pasture-based dairy herds differ in plasma lipid profiles

P2c: Milk as a diagnostic fluid to monitor viral diseases in dairy cattle

P2c: Milk as an indicator of dietary imbalance

P2c: Milk as a diagnostic fluid

P2e: Milk consumption and behaviour of calves in automated calf feeders as early indicators of weaning liveweight

P2e: Different lifetime dietary strategies affect carcass characteristics and rumen function in Holstein steers

P4: Field and in-silico analysis of harvest index variability in maize silage

P6a: An AI-based hybrid model for dairy cattle heat tolerance phenotype

P6a: Review: Ruminant heat-stress terminology

P6a: The diversity in dairy cattle reticulorumen temperature: Identifying water intake events

P9a: Sources of variation underlying the production of lactose by dairy cows

P9b: Graduate Student Literature Review: Potential use of heat shock protein 70 as an indicator of heat stress in dairy cows—A review

P9b: Skimming and storage factors affect the detection of heat shock protein 70 in raw bovine milk

P1a

scientific reports

OPEN

Accounting for minimum data required to train a machine learning model to accurately monitor Australian dairy pastures using remote sensing

Martin Correa-Luna[1✉], Juan Gargiulo[2], Peter Beale[3], David Deane[3], Jacob Leonard[3], Josh Hack[4], Zac Geldof[5], Chloe Wilson[1] & Sergio Garcia[1]

Precision in grazing management is highly dependent on accurate pasture monitoring. Typically, this is often overlooked because existing approaches are labour-intensive, need calibration, and are commonly perceived as inaccurate. Machine-learning processes harnessing big data, including remote sensing, can offer a new era of decision-support tools (DST) for pasture monitoring. Its application on-farm remains poor because of a lack of evidence about its accuracy. This study aimed at evaluating and quantifying the minimum data required to train a machine-learning satellite-based DST focusing on accurate pasture biomass prediction using this approach. Management data from 14 farms in New South Wales, Australia and measured pasture biomass throughout 12 consecutive months using a calibrated rising plate meter (RPM) as well as pasture biomass estimated using a DST based on high temporal/spatial resolution satellite images were available. Data were balanced according to farm and week of each month and randomly allocated for model evaluation (20%) and for progressive training (80%) as follows: 25% training subset (1W: week 1 in each month); 50% (2W: week 1 and 3); 75% (3W: week 1, 3, and 4); and 100% (4W: week 1 to 4). Pasture biomass estimates using the DST across all training datasets were evaluated against a calibrated rising plate meter (RPM) using mean-absolute error (MAE, kg DM/ha) among other statistics. Tukey's HSD test was used to determine the differences between MAE across all training datasets. Relative to the control (no training, MAE: 498 kg DM ha^{-1}) 1W did not improve the prediction accuracy of the DST ($P > 0.05$). With the 2W training dataset, the MAE decreased to 342 kg DM ha^{-1} ($P < 0.001$), while for the other training datasets, MAE decreased marginally ($P > 0.05$). This study accounts for minimal training data for a machine-learning DST to monitor pastures from satellites with comparable accuracy to a calibrated RPM which is considered the 'gold standard' for pasture biomass monitoring.

Keywords Machine learning, Model training, Remote sensing, Pasture grazing management

Pasture-based dairy systems remain appealing for a number of reasons, including the initial low investment needed on infrastructure[1] and their relatively low reliance on market commodity prices[2]. They are also socially well-perceived because of their positive environmental and animal welfare reputation[3], superior food nutritional quality produced from human-inedible feed[4–6], and the opportunity to be implemented where human edible crops cannot be economically cultivated[6]. For these systems to remain profitable, pasture conversion efficiency into milk would need to be maximized while maintaining a low production cost[7]. For this, it is especially important to have a balance between feed demand and supply while maintaining high proportion of grass eaten by lactating cows[2,8,9]. Since pasture is a 'living feed source', thus perishable, its quantity and quality changes throughout

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P1d

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Potential applications of a low-cost gas sensor to monitor enteric methane emission from ruminant animals

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ARTICLE INFO

Keywords:
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Hydrogen
Methane
MQ-4
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ABSTRACT

Enteric methane (CH_4) emissions are a significant concern in ruminant production due to its high global warming potential of 28 times that of CO_2. Research is focused on mitigating these emissions through animal and feed management. However, accurately and economically measuring CH_4 emissions from individual animals remains challenging due to current methods' high cost, slow speed, and labor intensity. Therefore, the primary objective of the present study was to evaluate low-cost gas sensors, named MQ-4, MQ-8, MQ-7, by comparing their data with a well-established GreenFeed system (GF). The MQ-4, MQ-8, and MQ-7are sensitive to CH_4, H_2, and CO, respectively. Sensors were assembled on a single board and placed at various points on the GF system (airflow outlet, pump outlet, and feed tray) to determine optimal placement. The pump outlet showed the highest correlation ($r = 0.51$ for CH_4 and $r = 0.65$ for H_2) with GF data. Following this, the gas sensors were placed in a pump outlet for 45 days, and enteric CH_4 and H_2 were measured simultaneously using both devices on 28 heifers, resulting in a total of 3.88×10^6 paired measurements. Correlation between CH_4 and H_2 data from the GF and gas sensors was assessed using Spearman correlation coefficients (SCC), repeatability, and peak measurement algorithms. The SCC values for the CH_4 concentration from the MQ-4 gas sensor and GF averaged weekly, daily, hourly, and minute were 0.62, 0.56, 0.49, and 0.47, respectively. The repeated measures correlation between (from the per second record) the devices was relatively low (0.30). The repeatability of CH_4 concentration was greater for the GF (0.31) than for the MQ-4 gas sensor (0.13). Additionally, there were significant differences in the detected number of peaks, peak duration, and width between the two devices. The peak detection algorithm indicated that the GF detected more peaks and processed data four times faster than the MQ-4 gas sensor. Although results indicate moderate and significant correlations between H_2 and CH_4 voltages measured by the GF and gas sensors, lower repeatability and discrepancies in peak characteristics observed for the gas sensor suggest caution in interchangeable use without further methodological refinement.

1. Introduction

Enteric methane (CH_4) production by ruminants poses a threat to climate change because it is a powerful greenhouse gas (GHG) with 28-fold greater global warming potential than carbon dioxide (CO_2) [1]. Enteric CH_4 accounts for 39 % of livestock sector emissions, making it a major concern worldwide [2]. Reducing such emissions from livestock can be addressed by combining feeding, genetic improvement, vaccines against methanogens, and management strategies [3–5]. However, accurate and large-scale measurements of GHG emissions from individual animals in their production environment are vital to develop and evaluate mitigation strategies and provide realistic GHG emission figures.

Numerous methods for quantifying enteric CH_4 emissions have been developed, each with its advantages and disadvantages [6–9]. One of the most accurate methods is the (closed-circuit) respiration chamber (RC), but it comes with limitations such as animal confinement, cost, and labor intensity, raising questions about its applicability to commercial or grazing systems [9]. In contrast, the (open-circuit) Greenfeed system (GF) offers higher throughput and shorter measurement periods [10]. However, GF's limitation lies in measuring gas exchange while animals

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P1d

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Dietary concentrate supplementation increases milk production and reduces predicted greenhouse gas emission intensity in pasture-based commercial dairy farms

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ABSTRACT

Controlled studies have extensively documented that concentrate supplements typically increase enteric CH_4 emissions and milk yield and reduce emissions per unit of milk produced and dry matter intake. However, no studies have been conducted to determine the effect of concentrate on predicted greenhouse gas emissions from dairy farms representing the Australian pasture-based farming system. Thus, this study sought to determine how dietary concentrate supplementation affects enteric and manure CH_4, and N_2O of Australian pasture-based dairy farms. The Australian Dairy Carbon Calculator was used, which incorporates emission factors and methodologies used in the National Greenhouse Gas Inventory as reported to the Intergovernmental Panel on Climate Change. Primary data were collected and analyzed from 120 commercial farms in Australia's major dairy regions. Then the farms were divided into 4 groups based on their dietary concentrate supplementation: ≤1 (low; 15 farms), 1 to 2 (moderate; 35 farms), 2 to 3 (high; 35 farms), and ≥3 (very high; 35 farms) t of concentrate dry matter (tDM) per cow per year. Sources of greenhouse gas emissions were CO_2 from concentrate production, enteric CH_4, and manure CH_4 and N_2O. Total dry matter intake, milk yield, and daily enteric CH_4 production (g/d) quadratically increased with concentrate level, whereas greenhouse gas emission intensity of milk production (kg of CO_2 equivalent per kg of fat- and protein-corrected milk) decreased by 14% for farms supplementing with ≥3 tDM/cow per year compared with those supplementing with ≤1 tDM/cow per year of dietary concentrate. The N_2O and CH_4 emissions from manure increased quadratically and linearly, respectively, with the increasing supplementation of concentrate. Farms supplementing 2 to 3 tDM/cow per year showed substantial increases in gross income, gross margin, earnings before interest and tax, and net income ($/cow per year) compared with those supplementing of ≤1, 1 to 2, and ≥3 tDM/cow per year. Overall, increasing dietary concentrate supplementation for dairy cows resulted in increased milk production per cow, reduced greenhouse gas emissions per unit of milk produced, and increased income and profit. However, a comprehensive life cycle assessment study is needed to account for carbon sequestration by other farm components, such as pastures and trees, which were not considered in the present study. In addition, the present study was based on modeling and did not gather ground truth information for DMI, digestibility, crude protein, and urinary and fecal N excretion. Therefore, data should be interpreted with caution, and studies gathering such information are encouraged.
Key words: milk yield, methane, nitrous oxide

INTRODUCTION

Methane and N_2O are the most important greenhouse gases (**GHG**) from dairy farms, with 28 and 265 times the global warming potential of CO_2, respectively, (IPCC, 2018). Methane is a short-lived climate pollutant, with an atmospheric perturbation lifetime of around 12.5 years (IPCC, 2014). In 2021, CH_4 concentrations were at 1,908 ppb, and N_2O concentrations were at 334.5 ppb in the atmosphere, representing 262% and 124% of pre-industrial levels, respectively (Citaristi, 2022). Methane and N_2O account for 16% and 6% of total global GHG emissions, respectively (Hockstad and Hanel, 2018). Methane from livestock contributes 5% of global GHG and 30% of anthropogenic CH_4 emissions (Jackson et al., 2020; Crippa et al., 2021). Enteric fermentation accounts for 88% of global livestock CH_4 emissions (FAO, 2019). The most significant source of GHG emissions from dairy production systems is enteric CH_4 (>70%), followed by N_2O (13%) and CH_4 (12%) from the animal waste of total on-farm non-CO_2 emissions (Eckard and Clark, 2018). The Australian dairy industry emits 10.0 Mt of CO_2 equivalent (**CO_{2eq}**), which accounts for 2% of total national emissions and 14% of agricultural emis-

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The list of standard abbreviations for JDS is available at adsa.org/jds-abbreviations-24. Nonstandard abbreviations are available in the Notes.

P2a

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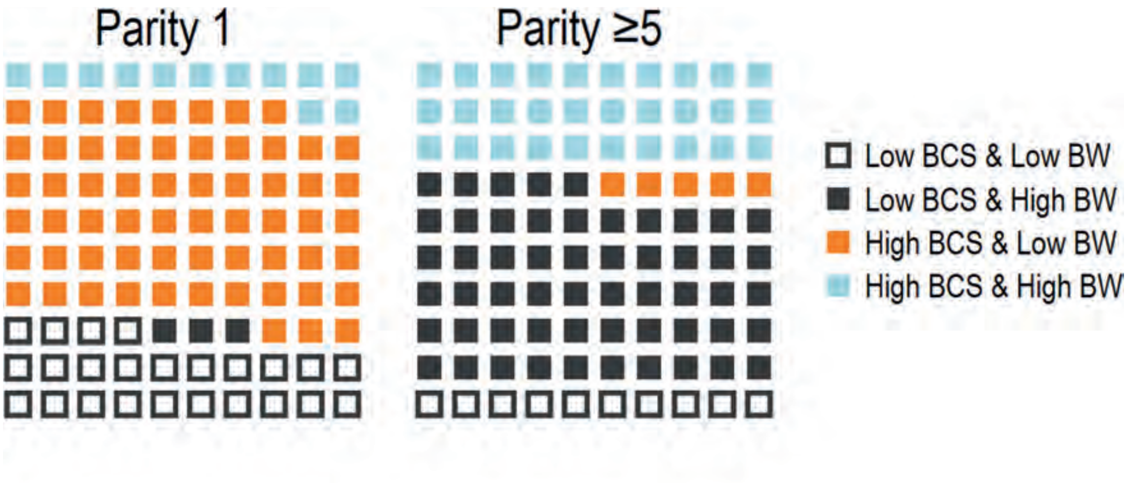
Short Communication
Health, Behavior, and Well-being

Holstein dairy cows lose body condition score and gain body weight with increasing parity in both pasture-based and total mixed ration herds

I. J. Lean,[1,2] D. B. Sheedy,[1,2*] S. J. LeBlanc,[3] T. Duffield,[3] J. E. P. Santos,[4] and H. M. Golder[1,2]

Graphical Abstract



Summary

Body condition scoring (BCS) and body weight (BW) measurements are associated with health and reproductive efficiencies of cows. We used raw data sets from 16 studies to evaluate associations of parity and feeding system (pasture-based or total mixed ration) with BCS at precalving and peak milk, and change in BCS, and BW at peak milk. With increasing parity, there is a general decrease in BCS and increase in BW regardless of feeding system, with most young cows having low BW and high BCS and older cows having high BW but low BCS.

Highlights

- Body condition score decreases and BW increases in older cows.
- Parity had a greater effect on BCS and BW than feeding system.
- Second-parity cows have the lowest pre-calving BCS.

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P2a

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Associations of parity with health disorders and blood metabolite concentrations in Holstein cows in different production systems

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ABSTRACT

Data were obtained from studies in Australia, Canada, and the United States using individual cow data from 28,230 Holstein cows to evaluate associations between parity and disease. Our goal was to develop understanding of disease risks for cows of differing parity. We hypothesized that there would be increased risks of disease and changes in metabolite concentrations with increased parity. Parity ≥5 represented 2,533 cows or 9.0%, parity 4 was 9.8% (2,778), parity 3 as 19.0% (5,355), parity 2 as 28.1% (7,925), and parity 1 was 34.1% (9,639) of the sample. Of these cows, 15.5% were in Australia, 14.7% in Canada, and 69.8% in the United States. Lactational incidence (LI) risk of clinical hypocalcemia increased with parity from 0.1% for parity 1 to 13% for parity ≥5 cows. The marked increase suggests profound differences in metabolism with increased parity. The LI of clinical mastitis was 17.4%. The odds of mastitis increased with parity to 2.5 times greater in parity ≥5 than in parity 1. The LI of lameness increased with parity; specifically, the odds of lameness was 5.6 times greater for parity ≥5 than parity 1. Dystocia incidence was 8.7% and greatest for parity 1 cows. The LI of retained placenta was 7.4% and increased with parity, with the odds for parity ≥5 2.3 times greater than for parity 1. The LI of metritis was 10% and of endometritis 14%, with the greatest odds in parity 1. The LI of clinical ketosis was 3.3% with a marked increase in odds with parity. The prevalence of subclinical ketosis was 26.8% with only cows in parity 1 having lower odds than other parities. Parity ≥5 cows had greater odds (odds ratio = 1.7) of respiratory disease than parity 1 cows, which were lesser than other parities. Metabolite concentrations were evaluated in 5,154 Holstein cows in the precalving, calving, and immediate postcalving data sets. Metabolic measures near peak lactation provided 1,906 observations. Concentrations of β-hydroxybutyrate (BHB) and nonesterified fatty acids increased with parity on d 1 to 3 of lactation and at peak lactation. On d 1 to 3 after calving differences in glucose, nonesterified fatty acids, and BHB indicated a greater reliance on mobilized lipid to export energy to peripheral tissues as BHB for greater parity cows. Differences in concentrations among parity groups were marked at times, for example >0.20 mM in Ca for parity 1 and 2 to parity ≥5 and >0.33 mM for all older parities compared with parity 1 for P on the day of calving. The marked increase suggests profound differences in metabolism with increased parity are probably influenced, in part, by increased production. We found marked differences in concentrations of metabolites with parity that are consistent with reduced reproduction, health, and body condition for higher parity cows. These unfavorable differences in metabolism in Ca, P, glucose, and cholesterol concentrations for higher parity cows also complement the often-substantial differences in disease risk with parity and suggest a need to carefully consider the parity structure in study design. Managers and advisors will need to consider methods to reduce risk of health disorders tailored to cows of different ages.

Key words: parity, disease, longevity, blood metabolites

INTRODUCTION

Many have noted a concern about the longevity of dairy cattle (De Vries and Marcondes, 2020; Dallago et al., 2021). Cows with parity ≥2 in a US-based study (Golder et al., 2019) and in large Australian studies were at 2 times greater risk for many diseases and had reduced odds and hazard of pregnancy than parity 1 cows (Golder et al., 2021). An evaluation of associa-

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Associations among body condition score, body weight, and serum biochemistry in dairy cows

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ABSTRACT

Body condition score and BW yield insights into body tissue reserves and diet, and serum biochemical measures reflect the metabolic status of cows. Associations between body composition measures and biochemistry are unclear and investigation may reveal important information on the metabolic and physiological status of cattle with varying levels of labile tissue reserves. Cohorts of 739 nonlactating, late-pregnancy, dry cows (26.9 d prepartum, SD = 12.4) and 690 peak-milk cows (58.0 DIM, SD = 14.5) were selected by stratified (parity: 1, 2, 3, >3) random sampling from 30 farms (15 pasture, 15 TMR) in this cross-sectional study. A single serum, BCS (1–5 scale), BW, and milk-production datum was collected per cow, per cohort between November 2022 and July 2023. Eleven analytes were collected, analyzed, and standardized within group (cohort/breed per farm). Mixed linear models for BCS and BW were specified, with the random effect of group. A 6-point, unordered, categorical body-group classification that combined BCS (greater, equal to, or less than group median; as high, median, or low BCS) and BW (greater or less than group median; as high or low BW) was analyzed by polytomous logistic regression. Effect sizes are listed for a 1 SD increase in the specified analyte, keeping other covariables at their mean value. Dry BCS was positively associated with albumin (0.075 BCS ± 0.014 SE), urea (0.038 BCS ± 0.014 SE), and glucose (0.052 BCS ± 0.014 SE), and negatively with the interaction between cholesterol and days precalving. Dry BW positively associated with albumin (11.03 kg ± 2.48 SE) and negatively with cholesterol (−8.47 kg ± 2.57 SE). Peak-milk BCS was positively associated with albumin (0.47 BCS ± 0.015 SE), BHB (0.048 BCS ± 0.015 SE), and glucose (0.051 BCS ± 0.015 SE). Peak-milk BW was positively associated with albumin (6.94 kg ± 2.35 SE) and negatively with Ca (−7.02 kg ± 2.33 SE). Increasing BW and decreasing BCS was associated with increasing parity, except in dry second-parity cows that had low BCS. The dry polytomous model associated a 1 SD increase in albumin with a 4.89% ± 1.56 SE decreased risk of being low BCS/low BW and 5.87% ± 1.46 SE increased risk of high BCS/high BW. Risk change associated with 1 SD of glucose was −5.61% ± 1.58 SE for low BCS/high BW and 3.17% ± 1.58 SE for high BCS/high BW. For the peak-milk cohort, change in risk was associated with albumin for low BCS/low BW −3.67% ± 1.56 SE, low BCS/high BW −3.22% ± 1.53 SE. Risk change with 1 SD of BHB was −3.36% ± 1.47 SE for median BCS/low BW, 2.86% ± 1.44 SE for high BCS/low BW, and 2.69% ± 1.37 SE for high BCS/high BW. Risk of low BCS/low BW was greatest in second-parity cows, and high BCS/high BW was greatest in dry cows with greater than third parity and third-parity cows in peak milk. There were no interactions between parity and analytes. Albumin was consistently associated with BCS and BW, potentially reflecting innate differences in protein metabolism of cows.

Key words: body condition, parity, albumin, protein, body weight

INTRODUCTION

Cows mobilize body reserves to facilitate the strong homeorhetic drive to produce large quantities of milk in early lactation (Bauman and Currie, 1980). This period of negative nutrient balance typically results in body condition and weight loss that reaches a nadir around 40 to 100 DIM (Westwood et al., 2002; Roche et al., 2009; Hernandez-Gotelli et al., 2023). Cows differ in their ability to partition and mobilize body reserves, with excessive mobilization associated with increased disease incidence, reproductive inefficiencies, and potentially poor cow welfare (Roche et al., 2009). Monitoring BCS

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A large multisite lipidomic investigation of parity and aging in dairy cows

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ABSTRACT

Efforts to optimize the longevity of dairy cows are hindered by the increased risk of adverse health events, culling, or dying on farm with increased parity. Lipidomics provides a platform to help identify important biomarkers and biological pathways associated with increased parity and associated aging. A large multisite (15 pasture-based, 15 TMR farms) cross-sectional study collected plasma samples from nonlactating, late pregnant, dry cows (n = 696, ~27 d prepartum) and peak milk cows (n = 796, ~58 DIM) in a disproportionate stratified random sampling frame (parity: 0, 1, 2, >2 for dry cows; 1, 2, 3, >3 for peak milk cows). A total of 185 lipid species, comprising the lipids classes of phospholipids, sphingomyelins (SM) and triacylglycerols, were quantified in a targeted, liquid chromatography-MS approach. Dry and peak milk cohorts were analyzed separately throughout. Variation in lipid profiles were mostly attributed to farm of origin (36%–41% of variation), with feeding system explaining 13% to 21% and parity explaining 6% to 9%, according to ANOVA simultaneous component analysis modeling. Multiple linear regression and orthogonal partial least squares (O-PLS) investigated the association of the lipid profile with age (d), whereas discriminant analysis compared first parity with >3 parity cows in O-PLS discriminant analysis, random forest, and support vector machine models. Rankings of the most important lipid species for each model type were compared. Phospholipids with 40 carbon atoms and 6 double bond equivalents (40:6) were consistently decreased with increasing parity and age across both dry and peak milk cohorts. These lipids most likely contained stearate (18:0) and docosahexaenoic acid (DHA, C22:6n-3), an n-3 fatty acid. Additionally, phospholipids with 40:5 and 38:6, lysophosphatidylcholine (17:0), SM(35:1), and SM(35:2) were commonly identified lipids that decreased in concentration with parity and age. Docosahexaenoic acid has been associated with improved cattle health, reproduction, and milk production and quality. This study raises the hypothesis that reduced DHA levels in older cows may be an important factor increasing susceptibility to adverse health events, reduced reproductive performance, and herd removal. Studies that supplement DHA or its precursors can test this hypothesis and may be important in optimizing longevity of cows.

Key words: lipids, parity, n-3 fatty acids, docosahexaenoic acid

INTRODUCTION

Optimal longevity of dairy cows is critical for farm profitability, cattle welfare, environmental sustainability, and the social license of the industry (Dallago et al., 2021). However, increased parity is associated with increased risk of adverse health events, being culled, or dying on farm (Lean et al., 2023a,b). To optimize longevity, it is critical to understand the underlying biology of increased parity. Lipidomics, the large-scale study of lipids, is a burgeoning and appropriate platform to help identify biomarkers and biological pathways associated with increased parity and associated aging (Wenk, 2005; Almeida et al., 2021).

For example, the phospholipid (**PL**) lipid class, which comprises of a phosphate containing hydrophilic core and 1 or 2 attached fatty acids (**FA**), are well recognized for their structural importance in the bilayers of cellular compartments, but are themselves highly diverse with wide-ranging functions that include associations with many diseases and aging (Harayama and Riezman, 2018; Dai et al., 2021). High levels of PL with PUFA are negatively associated with maximal age in many species, potentially due to high rates of peroxidation of PUFA and subsequent risk of oxidative damage (Hulbert

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Increased parity is negatively associated with survival and reproduction in different production systems

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ABSTRACT

We conducted a retrospective meta-analysis based on individual cow data to assess the associations of parity, level of production, and pasture-based or intensively fed systems with fertility. Our goal was to provide understandings of the role of parity in risks for removal and reproductive failure. Multilevel models were used to evaluate the fixed effects of parity, milk, milk solids, milk fat and protein percentage and yield, and production system [intensively fed (n = 28,675) or predominantly pasture fed (n = 4,108)] on reproductive outcomes. The outcomes were the hazard of not being bred (HNBRED), hazard of pregnancy (HPREG), pregnancy to first breeding (PREG1), and odds of becoming pregnant in a lactation (OPAL). The 32,783 cows were in 13 studies conducted in Australia (14.6% of cows), Canada (2.4% of cows), and the United States (83.0% of cows). There were 38.5% of cows in the sample in parity 1, 27.3% in parity 2, 16.7% in parity 3, 9.0% in parity 4, and 8.6% in parity ≥5. Compared with cows of parity 1, parity ≥5 cows had a greater HNBRED [hazard ratio (HR) = 2.45], lesser HPREG (HR = 0.73), and reduced OPAL (odds ratio = 0.36). However, the parity ≥5 cows had similar PREG1 to other parities except for parity 1. This suggests the possibility of a higher proportion of subfertile parity ≥5 cows than for other parities. Associations between parity and reproductive measures were influenced by the different milk production measures, indicating that milk yield and milk component percentages and yields modified the odds or hazards of successful reproduction. All milk production measures had quadratic associations with OPAL, indicating that either low or high production or concentration of solids within a cohort reduced OPAL. This reduced OPAL reflected a greater HNBRED for lower milk yield and milk protein and fat yielding cows. Both milk yield and milk protein percentage had quadratic associations with HPREG. When centered milk yield was categorized into quartiles, small differences in HPREG existed. A more marked association of milk protein percentage occurred with HPREG, with optimal HPREG at approximately 0.5% above group mean milk protein percentage. Milk fat percentage (HR = 0.901), fat yield (kg/d; HR = 0.78), protein yield (kg/d; HR = 0.71), and milk solids yield (kg/d; HR = 0.84) were all linearly associated with reduced HPREG. Difference in production systems did not have substantive effects on PREG1 but did for HNBRED, HPREG, and OPAL. Estimates of associations of parity with reproductive outcomes HNBRED, HPREG, and OPAL were influenced by milk and milk solids yield; older cows had markedly lower reproductive outcomes. Interestingly, for PREG1, there were few differences among parities and differences were less influenced by milk yield and constituent measures. The marked associations of parity with removal for all reasons, deaths and culling, and reductions in HNBRED, HPREG, and OPAL indicate a need to focus on the physiological changes with parity to produce better strategies to support optimal longevity of cows.
Key words: production, milk-protein, parity, pregnancy, longevity

INTRODUCTION

It is necessary to ensure that cows economically optimize their genetic potential by providing environments that permit them to be productive, healthy, and reproductively successful. Dallago et al. (2021) noted that the longevity of dairy cattle has decreased in most high milk-producing countries over time and that increasing longevity would have benefits including increased profitability. De Vries and Marcondes (2020) suggested that the economic trade-offs between longevity and profit may be complex given that rapid genetic gain is possible. A study conducted in the United States identified that more than 40% of cows

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Confinement and pasture-based dairy herds differ in plasma lipid profiles

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ABSTRACT

Dairy cow housing and management can be broadly described as either intensive confinement-based (CONFINE) or extensive pasture-based (PAST) systems. The diets between systems typically differ in their forage base, with CONFINE farms often utilizing maize silage in a TMR. Consequently, the lipid composition of diets differs between systems. The influence of housing system on blood lipidomics is currently unknown, but due to the bioactive role of lipids in influencing overall health and productivity, differences in diet may have consequences for reproduction, health, and aging of cows. The objective of this cross-sectional, multisite study was to investigate blood lipids and metabolites from cows in PAST and CONFINE systems, in the dry period (~27 d prepartum) and at peak milk (~58 DIM). After exclusions, blood samples from 303 PAST and 398 CONFINE dry-period cows and 350 PAST and 431 CONFINE peak-milk cows from 15 PAST and 15 CONFINE farms were analyzed. A total of 185 lipid species (including glycerophospholipids, sphingomyelins, and triacylglycerols) were evaluated using targeted liquid chromatography-MS, as were 11 routinely measured metabolites. Dry and peak-milk cohorts were analyzed separately throughout. Lipids and metabolites associated with housing system were selected using a variable stabilization approach that was achieved by calculating the frequency of inclusion in categorical (housing system) penalized models using bootstrapping. Variables were retained if inclusion frequency exceeded a false-positive threshold. Five different statistical models were used with variable stabilization. Dry cows in CONFINE systems had decreased globulin, urea, and glycerophospholipids associated with n-3 fatty acids. The highest total inclusion rates in the dry cohort were phosphatidylcholine (PC; 36:5), which mostly comprises palmitic acid (C16:0) and eicosapentaenoic acid (EPA; 20:5n-3), then phosphatidylethanolamine (PE; 38:5, 16:0/22:5n-3 or 18:0/EPA) and PC(34:3; 16:0/18:3 α-linolenic acid [ALA]). No lipids were increased in more than one stabilized model in CONFINE dry cows. Peak-milk CONFINE cows had increased glycerophospholipids associated with n-6 fatty acids. The highest total inclusion-rate lipids in the peak-milk cohort were phosphatidylinositol (PI; 38:3; 18:0/20:3n-6 dihomo-γ-linolenic acid), PC(34:2; 16:0/18:2 linoleic acid [LA]), PC(40:7; 18:2/22:5n-6), PC(34:1; 16:0/18:1), and PE(34:2; 16:0/LA). The CONFINE peak-milk cows also had decreased PC(34:3; 16:0/ALA). This study identified specific lipids that were strongly associated with housing systems, findings that have not been reported elsewhere. Given the important biological functions of omega fatty acids, the pattern of glycerophospholipids with increased n-6 and decreased n-3 in CONFINE cows may indicate housing systems create different risk profiles for reproduction, health, and aging.
Key words: lipidomics, omega fatty acid, housing, phospholipids

INTRODUCTION

Dairy cow housing systems can broadly be classified as either intensive confinement-based (**CONFINE**) or extensive pasture-based (**PAST**) systems. Beyond the inherent physical and managerial differences between these systems, diet composition typically differs substantially. Maize silage, a high DM yield forage, is commonly the main forage source in CONFINE systems and is provided as a component of a TMR. The distinct differences in lipid compositions of maize silage and fresh pasture may influence health, reproduction, and longevity of cows.

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PRODUCTION ANIMALS

INVITED REVIEW

Milk as a diagnostic fluid to monitor viral diseases in dairy cattle

B Brito[a,b,c*] and P Hick[a]

Background Infectious viral diseases in dairy cattle have substantial implications for milk production, quality and overall animal health. Diagnostic tools providing reliable results are crucial for effective disease control at the farm and industry level. Pooled or bulk tank milk (BTM) can be used as a cost-effective aggregate sample to assess herd disease status in dairy farms.

Findings Detection of pathogens or specific antibodies in milk can be used for monitoring endemic diseases within-farm, region or country-level disease surveillance and to make informed decisions on farm management. The suitability of assays applied to pooled milk samples relies on validation data of fit-for-purpose tests to design an optimal testing strategy. Diverse approaches and variable scope of studies determining test accuracy need to be critically appraised before sourcing the parameters to design sampling strategies and interpreting surveys. Determining if BTM or pooled milk is the best approach for a disease management programme should carefully consider several aspects that will impact the accuracy and interpretation, for example, the size of the lactating herd, the risk of infection in the lactating and non-lactating groups, the expected within-herd prevalence, the duration of infection, the duration and concentration of antibodies in milk and use of vaccination.

Conclusions There are examples of tests on BTM samples providing efficient assessments of the herd disease status and supporting disease control programmes for viral diseases. However, challenges arise in pooled milk testing due to the need for accurate estimates of the imperfect sensitivity and specificity of the assays. Integration of new biotechnologies could enhance multiplexing and data interpretation for comprehensive surveillance. The development of highly sensitive assays is necessary to meet the demands of larger dairy herds and improve disease detection and assessment.

Keywords aggregate samples; animal disease surveillance; diagnostic; virus

Abbreviations BoHV-1, bovine alphaherpesvirus-1; BLV, bovine leukosis virus; BTM, bulk tank milk; BVDV, bovine viral diarrhea virus; DIVA, differentiating infected from vaccinated animals; DSe, diagnostic sensitivity; DSp, diagnostic specificity; ELISA, enzyme linked immunosorbent assay; HSe, herd sensitivity; HSp, herd specificity; OD, optical density; PI, persistently infected; qRT-PCR, real-time reverse transcription polymerase chain reaction; VI, virus isolation

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Introduction

Infectious diseases in dairy cattle significantly impact milk production, quality and animal well-being. Effective disease management, control and surveillance are paramount to prevent outbreaks, safeguard human health from potential zoonotic infections and maintain sustainable dairy operations. Controlling infectious diseases is essential for preserving international trade opportunities and ensuring the overall health and productivity of dairy cattle. Several viral pathogens can cause subclinical, mild or severe diseases leading to significant economic losses to the industry. The intensification of the dairy industry allows for close monitoring of animals and the optimisation of productivity. However, animals with high physiological requirements and mixing cohorts with varying pathogen exposure create favourable conditions for disease caused by viral pathogens. A requisite to effectively control viral disease at the farm and industry level is the availability of diagnostic tools that provide reliable results for decision-making.

Tests of pooled milk can be a cost-effective tool for assessing disease status in a herd and for monitoring endemic viruses.[1,2] The combined milk collected from a dairy farm contains valuable target analytes that can identify infection or prior exposure to pathogens. Testing bulk milk has been critical in disease eradication programmes to determine herd infection status and to build confidence of freedom from infection for specific agents. However, the success of bulk milk testing depends on the informed use of assays that have been thoroughly validated. With the increasing size of lactating herds, the challenge lies in developing highly sensitive assays to detect diluted target analytes in large milk volumes of bulk tank milk (BTM). The accuracy of the assay must align with the testing objective, whether it is to assess an individual herd or for monitoring as part of an industry or government programme for disease control or eradication. For example, a study evaluating Caprine arthritis and encephalitis virus detection and control in Australian dairy goats found that antibody enzyme-linked immunosorbent assay (ELISA) testing of BTM can be a cost-effective strategy, particularly in herds with low infection prevalence. However, pooling approaches may not be beneficial in herds with higher infection rates.[3]

The viral infection dynamics, the concentration and persistence of antibodies or viruses in milk, as well as the expected herd prevalence, play a crucial role in determining the most effective approach for

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PRODUCTION ANIMALS

INVITED REVIEW

Milk as an indicator of dietary imbalance

IJ Lean[a,b*] and HM Golder[a,b]

Background Milk provides a readily available diagnostic fluid collected daily or more frequently on an individual animal or herd basis. Milk, as an aggregated sample in bulk tank milk (BTM) represents the status of a herd instead of a single animal. In this review, we examine the potential for milk to predict risks to efficient production, reproductive success, and health on the individual cow and herd level.

Findings For many conditions related to disorders of metabolism including hyperlipdaemia and ketonaemia, improved individual cow milk testing may allow a temporally useful detection of metabolic disorder that can target intervention. However, the extension of these tests to the BTM is made more difficult by the tight temporal clustering of disorder to early lactation and the consequent mixing of cows at even moderately different stages of lactation. Integrating herd recording demographic information with Fourier-transformed mid-infrared spectra (FT-MIR) can provide tests that are useful to identify cows with metabolic disorders. The interpretation of BTM urea and protein content provides useful indications of herd nutrition. These may provide indicators that encourage further investigations of nutritional influences on herd fertility but are unlikely to provide strong diagnostic value. The fat-to-protein ratio has a high specificity, but poor sensitivity for detection of fibre insufficiency and acidosis on an individual cow basis. Selenium, zinc, β-carotene, and vitamin E status of the herd can be determined using BTM.

Conclusions There appears to be increasing potential for the use of milk as a diagnostic fluid as more in-parlour tests become available for individual cows. However, the BTM appears to have under-utilised potential for herd monitoring.

Keywords bulk milk tank; dairy cattle; metabolism; nutrition

Abbreviations BTM, bulk tank milk; FFA, free fatty acids; FT-MIR, fourier-transformed mid-infrared spectra; MUN, milk urea nitrogen; NEFA, non-esterified fatty acids

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Milk provides a readily available diagnostic fluid collected daily or more frequently on an individual animal or herd basis. Milk, as an aggregated sample in bulk tank milk (BTM) represents the status of a herd instead of a single animal. In this review, we examine the potential for milk to predict risks to efficient production, reproductive success, and health on the individual cow and herd level. Our goal is to provide detail and evaluate existing tests to identify the potential to develop predictive models for dietary imbalance and metabolic disease including reproductive failure. The challenge of evaluating milk as a diagnostic fluid is substantial as one of the pre-conditions for producing a test that provides both sensitive and specific results is the issue of the definition of disease or disorder or having a rigorous index test. Lean et al.[1] note that definitions of disease often reflect historical understandings of disease (e.g., 'milk fever') or terms that reflect aspects of the perceived aetiology (e.g., 'grass tetany') and that classification of disease should be accurate and reflect standardised and repeatable criteria. They[1] noted that Evans postulates[2] should be applied to infectious disease and suggested a modification of these postulates that can be applied to define the metabolic disease. There are differences in case definitions throughout the literature reviewed for this study, hence overall assessments of test value may be more variable. For example, Tatone et al.[3] noted the variable thresholds in concentrations of ketones used to evaluate hyperketonaemia and evaluated three different ketone index tests against a reference standard of biochemical blood assay of 3-hydroxybutyrate (BHB). The challenge of case definition is far greater if one were to extend this to such a variably defined condition such as clinical ketosis.[1]

Diseases need not be 'clinical' to incur substantial costs on a herd, such as parasitic diseases[4] and there is considerable merit in monitoring the estimated prevalence in a population. There is also considerable merit in tests that identify epidemic diseases and provide alerts to the presence of these to allow timely interventions to prevent the spread.[5] The opportunity to diagnose metabolic disorders in individual cows may improve with better in-line detection systems; however, many of the disorders for which herds are at risk considered in this review may be better diagnosed at the herd level. Consequently, our review is both qualitative and quantitative and evaluates existing assays and those where milk assays may be valuable with a particular focus on BTM.

Energy deficiency and excess

The temporal clustering of metabolic disease to very early lactation limits the potential to use milk samples to diagnose hypocalcemia, hypomagnesemia, clinical ketosis, lipid mobilisation disorders, displaced abomasum, and metritis. Severe nutrient deficiency states for lactating cattle result from inappropriate management, primarily nutritional management, or disease. The genetic and phenotypic potential to produce greater amounts of milk and milk solids

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Milk as a diagnostic fluid

Over 40 years there have been profound changes to the Australian dairy production environment. The number of farms decreased from 21,989 in 1980 to 5055 in 2020,[1,2] milk production per cow increased from 2888 L/cow per year or 1.9 million cows producing 5.49 million L per year, to 6311 L/cow per year or 8.8 million L from 1.4 million cows. Many dairy farms represent assets valued in the $10 to $100 million or more. The average herd has increased from 85 to 274 cows. Consequently, farm management has less time to engage with the individual cow. These changes influence the delivery of veterinary services as the individual cow now represents a much lower proportion of the enterprise asset value. However, herd health and productivity are critical to an enterprise and farmers are committed to stewardship of their cattle. The challenge for the veterinary profession is to deliver cost-effective services that identify, monitor, and mitigate risks to herd health and productivity. Such services must be designed to deliver better outcomes with greater labour efficiency. In this series of reviews, we evaluate the value of bulk tank milk which provides a readily available and contemporary indicator of herd status of health and production and, where appropriate, compare the value of bulk milk testing to that of individual cow testing, to determine the mastitis,[3] viral,[4] and metabolic status[5] of herds. We provide quantitative and qualitative reviews of tests that may do this. We also note two coincident and valuable scoping reviews of this area,[6,7] one of which includes data on the value of bulk tank milk for parasite evaluation.[7]

Bulk milk somatic cell counts are routinely utilised by processors and veterinary advisors to assess milk quality and udder health. Because this assessment does not capture cows with clinical mastitis, diagnostics at the cow level may also be needed to manage udder health. Additional markers of inflammation or the humoral immune response are primarily available at cow level, except for antibody testing for *Mycoplasma bovis*, which can be conducted at bulk milk level to support biosecurity efforts. Elevated somatic cell counts are primarily due to intramammary infections, and its causative agents, including those with antimicrobial resistance, can be detected through culture or PCR. Specificity of PCR for contagious pathogens (*Streptococcus agalactiae*, *Mycoplasma bovis*) is high (0.90) but sensitivity is variable (0.15–0.99) unless repeated bulk milk testing or cow-level testing is used. For pathogens that may be cow-derived as well as environmental (*Staphylococcus aureus*, *Streptococcus dysgalactiae*, *Streptococcus uberis*), sensitivity of bulk milk testing is low (<30%).[3] New technologies such as matrix-assisted laser desorption/ionization time of flight (MALDI-TOF) or loop-mediated isothermal amplification (LAMP) offer new insights into intramammary infection but are not applied at the bulk milk level yet.

Bulk tank milk was very effectively used in Australia to evaluate herd status with an ELISA test to eradicate bovine leukaemia virus. Interpreting results from bulk milk tests requires careful consideration of complexities, including the test target, prior virus exposure including vaccination, duration of antibodies in milk or virus shedding, and other relevant factors. For direct detection of pathogens or the immune or metabolic responses to pathogens, increased herd size and prevalence of organisms or response has significant testing implications. Specifically, as herd size increases the probability of the assay detecting the presence decreases due to potential for dilution. Studies identified the limits of detection for different assays and estimates for herd sensitivity (0.44–0.97) and herd specificity (0.42–1.00) for pestivirus ELISA.[4] The use of PCR to detect persistently infected animals detected up to 1 animal in 1000, however, other studies indicated a lower sensitivity. Bulk tank milk can also be used to detect bovine alphaherpesvirus-1 (BHV-1) which is prevalent in Australia, while the use during a foreign animal disease outbreak is arguable.

There are valuable bulk tank milk assays that can monitor the herd nutritional status.[5] The bulk tank milk urea and protein content provide useful indications of herd nutrition using routine milk testing from milk processors. These tests provide indicators that encourage further investigations of nutritional influences on herd fertility but are unlikely to provide strong diagnostic value. The fat to protein ratio has a high specificity, but poor sensitivity for the detection of fibre insufficiency and acidosis on an individual cow basis and is useful as an alert to evaluate other indicators of acidosis in a herd. Integrating herd recording demographic information with Fourier-transformed mid-infrared spectra (FT-MIR) can provide tests that are useful to identify cows with metabolic disorders and these tests will become more available in Australia. Selenium, zinc, β-carotene, and vitamin E status of the herd can be determined using bulk tank milk and could be combined to monitor herds.

Bulk tank milk is an under-utilised resource that can be used to improve the health and productivity of dairy herds. There is considerable potential to increase the availability and adoption of bulk tank milk as part of an efficient integrated farm service. Some of the tests readily available and reported on a daily basis include milk volume, somatic cell counts, fat, protein, and milk urea. More can be done with these data to evaluate herds. However, there appears to be increased scope for testing for milk minerals, vitamins, and assays for mastitis and viral pathogens. These assays can provide cost-effective rapid means of monitoring herds and have the potential to be integrated with statistical monitoring methods to automate detection of changes in herd status and equip veterinary services with new tools to assist farms.

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Short Communication
Health, Welfare, and Behavior

Milk consumption and behavior of calves in automated calf feeders as early indicators of weaning liveweight

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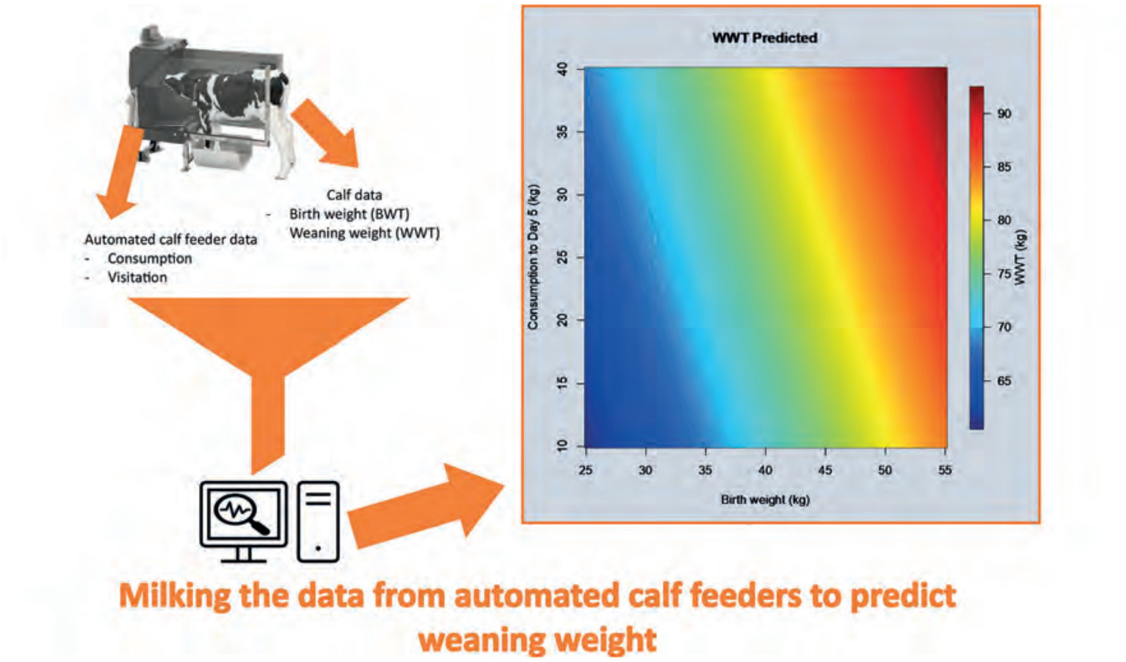
Graphical Abstract



Summary

This study suggests that by monitoring calves' consumption and visitation frequency using automated calf feeders on day 5, farmers can identify underperforming calves early, allowing for timely intervention to boost their growth potential. Additionally, calves exhibiting higher milk consumption and increased interaction with the feeder during the first 5 days are more likely to achieve a weaning weight exceeding 75 kg. This highlights an opportunity for management intervention in cases where calves fall below these consumption and interaction thresholds.

Highlights

- Weaning weight among calves showed considerable variability, ranging from 41 to 118 kg.
- Milk consumption and number of visits are strong indicators of performance.
- Intervention points could be effective as early as 5 days.

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ANIMAL PRODUCTION SCIENCE

Different lifetime dietary strategies affect carcass characteristics and rumen function in Holstein steers

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ABSTRACT

Context. How to improve integration of male dairy calves into red meat supply chains. **Aims.** To evaluate the effects of two diets differing primarily in starch, antimicrobial content and milk replacer volume on: (1) short- and long-term rumen adaptation; and (2) lifetime production in Holstein steers. **Methods.** Holstein males, 3–7 days old (n = 72; 36 steers/treatment; six per replicate), were randomised to control (CON; 6 L milk replacer/calf.day; 38.2% of DM lifetime dietary starch; 50 ppm monensin, 20 ppm flavophospholipol) or treatment (TRT; 4 L milk replacer/calf.day; 47.5% of DM lifetime starch diets with yeast products) strategies. Calves were fed milk replacer twice daily for 42 days, but different pre-starter (Days 0–24), starter (Days 25–99) and finisher diets (Days 100–452). Ruminal fluid was collected at 104, 200 and 438 days old (14 days pre-slaughter) from 24 steers (2 per replicate). Fermentation, production and carcass measures were analysed by mixed models; ruminal bacterial genera were centre log transformed and subjected to redundancy analysis. **Key results.** The CON group had a higher risk of subclinical ruminal acidosis at Day 438 than the TRT group ($P < 0.001$). Liver abnormalities were 17.1% (CON) and 31.3% (TRT). The CON group had greater fermentation, with 138.4 ± 5.6 mM of total volatile fatty acids versus 111.6 ± 5.6 mM (TRT), and 8.4 mM higher acetate and 18.1 mM higher propionate, but pH was 0.31 units less ($P < 0.050$). Shannon diversity increased over time ($P < 0.001$) and was greater for the TRT group at Day 200, compared with the CON group ($P = 0.013$). Bacterial composition differed at each treatment by time comparison ($P \leq 0.01$), with variation increasing over time from 8.6 to 19.2%, suggesting the different diets lead to different microbial successions. The CON steers finished with 12 kg heavier carcasses than the TRT steers, with 0.8% greater dressing percentage, 1.5 mm more fat at P8 and 1.7 mm more rib fat ($P < 0.050$). **Conclusions.** CON diets produced better carcass weights, P8 and rib fat, and had more fermentability than the TRT diets, likely reflecting better long-term adaptation. **Implications.** Both diets enabled integration of dairy calves into the red meat supply chain, but with differing lifetime rumen adaptations.

Keywords: carcass weight, dairy beef, flavophospholipol, liver abscess, monensin, rumen adaption, rumen microbiome, ruminal acidosis.

Introduction

The Australian dairy industry has a considerable surplus of male dairy calves for which there are limited markets and animal welfare concerns (Vicic *et al.* 2022; Bolton *et al.* 2024); a challenge also faced by other countries (Creutzinger *et al.* 2021; Maher *et al.* 2021; Van Selm *et al.* 2021). There is a need to improve how 'dairy beef', the term for meat that originated directly or indirectly from dairy herds (Berry 2021), is integrated into red meat supply chains. Consequently, the challenge that exists with dairy beef is how to efficiently utilise the opportunity that these calves provide.

Diets with a high starch content (Hill *et al.* 2016; Hu *et al.* 2018; Chishti *et al.* 2021) or that use in-feed antimicrobials, such as monensin, tylosin and flavophospholipol, to stabilise the rumen (Pfaller 2006; El-Waziry *et al.* 2022; Asad *et al.* 2023; Firkins and Mitchell 2023)

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Field and in-silico analysis of harvest index variability in maize silage

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Maize silage is a key component of feed rations in dairy systems due to its high forage and grain yield, water use efficiency, and energy content. However, maize silage nutritive value can be compromised by in-season changes during crop development due to changes in plant partitioning between grain and other biomass fractions. The partitioning to grain (harvest index, HI) is affected by the interactions between genotype (G) × environment (E) × management (M). Thus, modelling tools could assist in accurately predicting changes during the in-season crop partitioning and composition and, from these, the HI of maize silage. Our objectives were to (i) identify the main drivers of grain yield and HI variability, (ii) calibrate the Agricultural Production Systems Simulator (APSIM) to estimate crop growth, development, and plant partitioning using detailed experimental field data, and (iii) explore the main sources of HI variance in a wide range of G × E × M combinations. Nitrogen (N) rates, sowing date, harvest date, plant density, irrigation rates, and genotype data were used from four field experiments to assess the main drivers of HI variability and to calibrate the maize crop module in APSIM. Then, the model was run for a complete range of G × E × M combinations across 50 years. Experimental data demonstrated that the main drivers of observed HI variability were genotype and water status. The model accurately simulated phenology [leaf number and canopy green cover; Concordance Correlation Coefficient (CCC)=0.79-0.97, and Root Mean Square Percentage Error (RMSPE)=13%] and crop growth (total aboveground biomass, grain + cob, leaf, and stover weight; CCC=0.86-0.94 and RMSPE=23-39%). In addition, for HI, CCC was high (0.78) with an RMSPE of 12%. The long-term scenario analysis exercise showed that genotype and N rate contributed to 44% and 36% of the HI variance. Our study demonstrated that APSIM is a suitable tool to estimate maize

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An AI-based hybrid model for dairy cattle heat tolerance phenotype

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ABSTRACT

Extreme weather events pose substantial risks to dairy cattle production and welfare, with heat stress being a major disruptor. Current approaches for heat tolerance phenotype selection in dairy cattle primarily utilise statistical models. We propose a novel hybrid AI-based method (HAIM) to enhance the selection of heat-tolerant cattle. It integrates AI with a statistical genetics model that links heat tolerance to decline in milk yield as the Temperature-Humidity Index (THI) rises above 60. This decline is modelled at both herd and individual levels, with the individual decline per unit increase in THI represented by the random slope and the intercept providing the baseline.

For this modelling, 20 years of climate data were combined with New South Wales Holstein dairy cow production data, covering the same period and resulting in 3 million records. The HAIM model demonstrated a smaller standard deviation of residuals (3.25 L/cow/test day) compared to the statistical model (3.37 L/cow/test day). A high correlation ($R^2 = 0.93$) between the random slopes estimated by both models indicated similar heat tolerance estimates, with the AI-based model showing lower standard deviation of residuals. A negative association between estimated random intercepts and slopes highlighted that high-producing animals are more vulnerable to heat stress. These findings emphasise the importance of considering both traits (random slopes and intercepts) to improve heat tolerance selection without compromising overall production levels. The proposed model combines the strengths of statistical modelling with the capabilities of AI, resulting in a more accurate and efficient means of identifying heat-tolerant cattle.

1. Introduction

The global demand for dairy production is surging due to population growth [7]. Nevertheless, climate change and extreme weather events pose substantial risks to dairy cattle production and welfare with heat stress being a major disruptor [27]. Heat stress, caused by high temperatures and humidity, can significantly reduce milk yield, fertility, and overall well-being of cattle [3,26,29,35]. Such changes in climate are particularly pertinent for the Australian dairy industry, as the country encounters some of the world's most elevated temperatures and climate variability, while simultaneously being a significant exporter of dairy products [48].

Although the adoption of efficient management practices can substantially reduce the effects of heat stress, advancements in genomics offer further solutions. Techniques such as genomic selection and gene editing now allow breeders to pinpoint animals with superior genetics at a younger age [50]. Genomic selection is a breeding technique that has been increasingly adopted in the dairy cattle industry [23,51]. This has enabled the creation of new breeding values that utilise phenotypes from specific reference populations of genotyped cows. Egger-Danner et al. [20] have examined prospective candidate traits for new breeding values, focusing on expected health and fitness traits. In this regard, heat tolerance in dairy cattle could be improved using genomic selection, with the development and application of genomic breeding values for heat tolerance which have been predicted to reduce the decline in milk production and reduce increases in core body temperature [21]. Recently, Australian researchers have made significant strides in this area, demonstrating the first attempt to incorporate heat tolerance (HT) into selection indices for dairy cattle [32]. Furthermore, they introduced a new innovative trait: HT genomic breeding values [31], which has been incorporated into the national selection indices of Australia [36].

The development of the HT breading values, as presented by Nguyen et al. [33]; Nguyen et al. [31], is based on prior research that employed temperature-humidity indices (THI) as an indicator of heat load and

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Review: Ruminant heat-stress terminology

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ABSTRACT

With increasing climate variability, there is a rise in the exposure to, and incidence of, ruminant heat stress (**HS**), increasing the requirement for focused research. As such, precise terminology is crucial to maintain effective communication and knowledge advancement. Despite this, several key terms are currently defined inconsistently, leading to confusion and misinterpretation. This paper examines the historical and contemporary use of the terms 'resistance', 'tolerance', 'resilience', and 'susceptibility' across various disciplines, revealing significant ambiguities that hinder both research and practice. Through this comprehensive review, we propose new definitions for each term as they are used relating to HS, with a focus on ruminant production. Proposed definitions align with current scientific understanding, providing a robust framework for future research and application. As further research is conducted, we hope these definitions can be improved through the inclusion of quantitative measures which align with these classifications. This present review provides definition clarity for common heat abatement terminology, enabling consistency and from this, progress in the field to ameliorate HS for ruminants.

Implications

The exposure of livestock to climate variability and the associated risks of heat stress is increasing, warranting the development of heat abatement techniques. Whilst various mitigation strategies have been identified, poor clarity and consistency across heat tolerance terminology remain. This review provides definition clarity for common heat abatement terminology, enabling consistency and from this, progress in the field to ameliorate heat stress.

Introduction

Ruminant production in Australia occurs in a wide range of environments, with most livestock exposed to climate variability and the associated risk of heat stress (**HS**) (Cowley et al., 2015; Cheruiyot et al., 2019). Alongside these climate changes has been production intensification, compounding the impact of HS worldwide (Renaudeau et al., 2012; Polsky and von Keyserlingk, 2017; Islam et al., 2021). High-producing animals are particularly vulnerable to HS due to their greater metabolic rates and energy requirements as compared to lower–producing contemporaries (Ravagnolo and Misztal, 2000; Collier et al., 2019). With global projections requiring milk production to double in the next five decades (Britt et al., 2018) and the World Health Organization recognising a notable rise in the demand for animal-derived protein in all regions (Henchion et al., 2021), investigation of heat abatement techniques is vital to minimise and ameliorate heat stress and with this, maintain or enhance animal welfare standards and production outputs.

To ameliorate HS in ruminants, there are three management strategies: genetic development of resistant breeds, nutritional management, and physical modification of the environment (Beede and Collier, 1986; Johnson, 2018). Irrespective of strategy, the identification of an individual animal's ability to cope under HS conditions is essential for effective implementation. Despite this, there is poor clarity across heat tolerance terminology, leading to ambiguity. Ambiguity with regard to HS terminology is problematic due to resulting confusion and miscommunication among researchers, disciplines, and industries. For instance, the terms 'resistance', 'tolerance', 'resilience', and 'susceptibility' are used interchangeably despite their distinct meanings.

Resistance is typically viewed as an innate ability that enables an organism to defend itself from disease agents (Best et al., 2008; Schneider and Ayres, 2008), though variability in the classification of this term remains. Tolerance is primarily associated with a degree of endurance, defined by the slope of a reaction norm (West-Eberhard, 2008), but has other interpretations. Definitions of resilience primarily account for an encapsulation of change and ability to recover at speed (Gunderson and Holling, 2002;

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The diversity in dairy cattle reticulorumen temperature: Identifying water intake events

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ABSTRACT

Climate change and associated weather variability across the Australian landscape has lent themselves to an increased incidence of cattle heat stress. Water consumption can have a sizeable, sustained impact on reticulorumen temperature readings, thereby impacting our interpretation of an individual's underlying physiological response to changing environmental conditions. To distinguish drinking events, we developed a drinking event detection model based on observed drinking events (video recording) from 28 dairy heifers, alongside sensor-derived reticulorumen temperature (smaXtec Animal Care GmbH) profiles. The optimised model identified drinking events with high accuracy (F-score = 0.99), as predicted when the average reticulorumen temperature declined by at least 0.5°C per 10-minutes, over a 10-, 20-, or 30-minute period. To account for differences in rapidity of decline, smaller reductions of 0.25°C per 10 min were considered valid indicators of a drinking event, provided the 0.5°C per 10-minute threshold was also met in a consecutive observation period. The temporal variability in drinking behaviour for 1,429 lactating dairy cattle across three dairy farms was then determined. Daily drinking events were greater in summer (mean 4.1) than winter (mean 3.3), while the change in reticulorumen temperature with each drinking event was smaller in summer (mean 3.7°C) than winter (mean 4.9°C). Drinking-recovery duration averaged 97.8 min/event. By revealing temporal differences in drinking behaviour for pasture-based dairy cattle, this work provides the basis for an improved understanding of core body temperature diversity.

1. Introduction

Dairy farming in Australia is primarily pasture-based and occurs across a wide range of environments (Cheruiyot et al., 2019). As such, Australian dairy cattle are increasingly exposed to climate variability and with more frequent, intense heat events the associated risk of cattle heat stress (HS) also increases (Blunden and Boyer, 2022; Cowley et al., 2015). Climate change is of particular importance for high-yielding dairy cows as they already experience an elevated internal heat load compared to lower producing individuals (Pryce et al., 2022), and as a result, the impact of heat accumulation is exacerbated for these cows (Bernabucci et al., 2015; West, 2003). As a response to escalating global temperatures, there is an increasing need to understand the role of climate factors and their impact on the prediction and assessment of HS for dairy cattle (Yan et al., 2020). Several thermal indices are used by livestock industries (Wang et al., 2018a) including the temperature humidity index (Mader et al., 2006), heat load index (Gaughan et al., 2008), comprehensive climate index (Mader et al., 2010), index of thermal stress for cows (Da Silva et al., 2015), dairy heat load index (Lees et al., 2018), and equivalent temperature index for cattle (Wang et al., 2018b), among others. However, the success of a thermal index is intimately linked with its ability to predict animal responses to heat (Hahn et al., 2009). As most thermal indices predictions are at a herd-level, methods to determine individual animal responses to HS are required.

An animal's primary response to a challenging thermal environment is the alteration of its physiology and/or behaviour (Ji et al., 2020; Polsky and von Keyserlingk, 2017; West, 2003). Cattle response to HS can appear in a variety of forms, however each response aims to reduce metabolic heat production and enhance heat dissipation into the environment (Islam et al., 2021; West, 2003). Due to advances in precision livestock farming, the use of objective technology is enabling

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Sources of variation underlying the production of lactose by dairy cows

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ABSTRACT

This study explored variability in the production of lactose by dairy cows, and the factors underlying it, using herd testing data from New South Wales, Australia. The dataset spanned 14 years (2008–2022) and comprised 393,772 records from 33,280 cows across 85 herds, alongside meteorological and dairy sire genetic data. Variables included milk yield, composition, and quality; reproductive data; breed information; and environmental factors. We found significant variation in lactose yield (LY), lactose percentage (LP), and milk solids yield (MSY) across breed, parity, and stage of lactation. Holsteins had the highest LY and MSY and the lowest LP, whereas Jerseys produced more MSY per unit of LY (MSY:LY ratio). We observed a negative correlation between LY and milk composition variables (fat and protein percentages) and environmental factors such as the temperature-humidity index. Heritability estimates indicated a moderate genetic influence on LY, LP, and MSY:LY (0.24–0.33). The identification of cows producing milk with a consistently lower LP or higher MSY:LY ratio highlights the potential for selective breeding against lactose output to increase the production of milk components and suppress milk volume. These findings highlight the potential to modulate lactose synthesis that could enhance the milk production efficiency of dairy cows, and potentially reduce their environmental impact.
Key words: lactose, variability, dairy industry, productivity

INTRODUCTION

Lactose is the main carbohydrate in cow milk and makes a substantial contribution to its energy content (Tyrrell and Reid, 1965). The biosynthesis of lactose occurs in mammary epithelial cells, which utilize ~65%–70% of the available glucose present in the bloodstream of cows during peak lactation (Baumgard et al., 2017). This intracellular synthesis of lactose establishes an osmotic gradient, drawing water into the epithelium, thereby increasing milk volume (Sadovnikova et al., 2021). Lactose output is positively correlated with the output of milk fat and protein, where the concentration of these components in milk can vary due to a range of different genetic and environmental factors (Osorio et al., 2016; Costa et al., 2019b).

Lactose is also a versatile ingredient that functions as a sweetener, bulking agent, source of energy, and flavor enhancer in various food products (Huppertz and Gazi, 2016). In the pharmaceutical industry, lactose is used as an excipient in drug delivery systems, and it also plays a pivotal role in the production of lactulose (Gänzle et al., 2008). In countries such as New Zealand, lactose is imported to standardize the level of milk components in products such as whole milk powder (Sneddon et al., 2013). However, it is noteworthy that lactose is often excluded from milk payment systems for dairy farmers. In fact, many companies apply volume charge deductions, which inadvertently penalize for lactose production, and only a few incentivize dairy farmers to increase lactose production by factoring it into the payment system (Costa et al., 2019a).

Reducing lactose synthesis and consequent milk volume, without affecting the secretion of other milk components, could result in economic, environmental, and social benefits for the dairy industry. For example, processors would benefit from reduced transport and storage costs (Garrick and Lopez-Villalobos, 2000), increased yields of dairy products, lower water and energy usage, and reduced waste (Haile-Mariam and Pryce, 2017). Additionally, producing the same amount of saleable milk solids (i.e., fat and protein) with a lower lactose output would provide comparable income to farmers while potentially reducing their cows' energy demands, lowering their risk for metabolic diseases, and improving their reproductive performance (Collard et al., 2000). A similar amount of milk solids could also be harvested each day from fewer milkings, or with flexible milking times, leading to positive impacts on

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Graduate Student Literature Review: Potential use of heat shock protein 70 as an indicator of heat stress in dairy cows—A review*

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ABSTRACT

Heat stress (HS) poses significant challenges to the dairy industry, resulting in reduced milk production, impaired reproductive performance, and compromised animal welfare. Therefore, understanding the molecular mechanisms underlying cellular responses to HS is crucial for developing effective strategies to mitigate its adverse effects. Heat shock protein 70 (HSP70) has emerged as a potential player involved in cellular thermotolerance in dairy cows. This review provides a comprehensive overview of the role of HSP70 as a molecular chaperone in cellular thermotolerance in dairy cows under HS. HSP70 facilitates proper protein folding and prevents the aggregation of denatured proteins. By binding to misfolded proteins, it helps maintain protein homeostasis and prevents the accumulation of damaged proteins during HS. Additionally, HSP70 interacts with various regulatory proteins and signaling pathways, contributing to the cellular adaptive response to HS. The upregulation of HSP70 expression in response to HS is regulated by a complex network involving heat shock factors (HSF), heat shock element-binding proteins, and HSF co-chaperones. Therefore, HSP70 holds the potential to be a useful indicator of tissue stress due to its role in maintaining cellular balance and because it is released both inside and outside cells in response to stress. Traditional methods of measuring HSP70 in blood samples are labor intensive, and because the process is potentially stressful for the animals, this may subsequently affect the results. Therefore, measuring HSP expression in cow milk has shown promise as an easy, noninvasive, and accurate way to detect HS in dairy cows. Monitoring HSP70 levels in milk can be applied as a supplementary approach to identify HS or HS resistance of individual cows, select suitable animals, and guide targeted management strategies. However, despite the potential advantages of using HSP70 as a biomarker for monitoring HS on dairy cows, challenges remain in standardizing measurement protocols, establishing species-specific reference ranges, addressing interindividual variations, and determining the specificity of changes in HSP70 due to HS. Future research should focus on developing noninvasive techniques for HSP70 detection, with consideration of climatic conditions and unraveling the molecular interactions and regulatory networks involving HSP70.
Key words: animal welfare, biomarker, ELISA, heat shock protein, milk

INTRODUCTION

Heat stress (**HS**) in dairy cows refers to an environment that raises the body temperature of cows due to exposure to high temperatures and humidity levels beyond their ability to dissipate heat effectively (Dunshea et al., 2013; Hyder et al., 2017). This can lead to reduced feed intake, lower milk production, and compromised reproductive performance in cows (Bernabucci et al., 2014; Polsky and Von Keyserlingk, 2017; Becker et al., 2020; Rakib et al., 2020). To cope with HS, cows attempt to regulate their body temperature through panting and sweating, leading to increased water consumption and dehydration (Islam et al., 2021). A combination of observed behavioral changes and physiological indicators are used to diagnose HS in cows, including monitoring increased respiration rates, rectal temperature, panting, drooling, and reduced activity (Tresoldi et al., 2018).

The ability of an animal to maintain homeostasis in response to thermal stress is known as thermotolerance, and it is essential for survival under these conditions. Heat shock proteins (**HSP**) are a class of molecular chaperones (i.e., assistants or helpers) that play a crucial role in maintaining cellular homeostasis and promoting thermotolerance in cells exposed to high temperatures (Mayer and

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Short Communication
Physiology

Skimming and storage factors affect the detection of heat shock protein 70 in raw bovine milk

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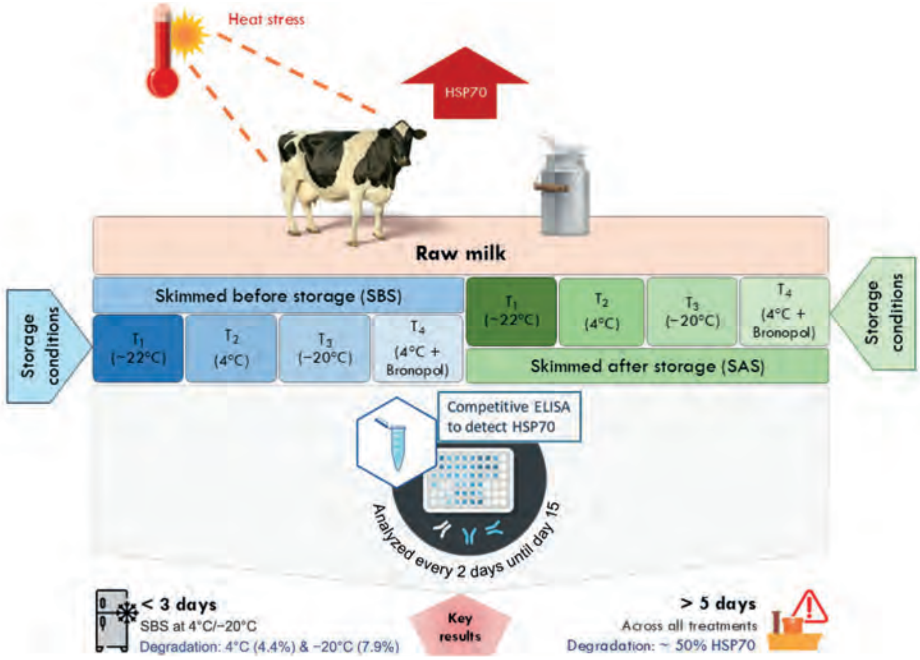
Graphical Abstract



Summary

This study evaluated the impact of milk sample handling on the detection of heat shock protein 70 (HSP70) in bovine milk by using a competitive enzyme-linked immunosorbent assay (ELISA) system. Samples were processed as skimmed before storage (SBS) or skimmed after storage (SAS) and stored under various conditions: room temperature (~22°C; T_1), refrigeration (4°C; T_2), freezing (−20°C; T_3), and refrigeration with preservative (4°C + bronopol; T_4). Samples were analyzed every 2 days over 15 days to assess HSP70 stability. Results showed that SBS samples stored at 4°C or −20°C for up to 3 days preserved HSP70 levels with minimal degradation (4.4% and 7.9%, respectively), whereas SAS samples showed significantly higher degradation (44.2%–53.9%). Room temperature storage led to the greatest degradation, and bronopol use did not consistently maintain HSP70 levels. These findings highlight the importance of optimizing milk storage to preserve HSP70, a potential biomarker for cellular and heat stress in dairy cows.

Highlights

- Skimming milk before storage reduces HSP70 degradation compared with after storage.
- Skim milk stored at 4°C or −20°C preserves HSP70 levels effectively for up to 3 days.
- Storage beyond 5 days causes ~50% HSP70 degradation across all treatments.

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The list of standard abbreviations for JDSC is available at adsa.org/jdsc-abbreviations-25. Nonstandard abbreviations are available in the Notes.

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