June 2019

Issue 42

TECHNICAL SERIES

SCIENCE IN ACTION

HEIFER PUBERTY: AN EARLY INDICATOR OF COW FERTILITY?

Improving mastitis detection

Can we reduce disbudding pain?

Linking cow breed and profit

DairyNZ

CONTENTS

We appreciate your feedback

Email technicalseries@dairynz.co.nz or call us on 0800 4 DairyNZ (0800 4 324 7969). Alternatively, post to: Technical Series, Private Bag 3221, Hamilton 3240.

This publication is printed using vegetable-based inks on paper which is Forest Stewardship Council® (FSC®) certified, mixed source pulp from responsible sources.

Paper produced using Elemental Chlorine Free (ECF) and manufactured under the strict ISO14001 Environmental Management System.

To find out how to recycle the plastic wrap used to protect this magazine during postage, visit **dairynz.co.nz/insidedairy**

ISSN 2230-2396

DNZ04-041

Genetics and liveweight gain influence heifer puberty timing

DairyNZ's latest research indicates an 'age at puberty' trait has potential to increase the rate of genetic improvement in cow fertility. Two of the greatest influences on the timing of puberty are liveweight gain and genetics.

High and low Fertility Breeding Value heifers before puberty.



Chris Burke, senior scientist, DairyNZ
Susanne Meier, senior scientist, DairyNZ
Claire Phyn, senior scientist, DairyNZ

Why is 'age at puberty' important?

First-calving heifers make up approximately 20 percent of the herd. To calve between 22 to 24 months old, heifers need to get in calf between 13 to 15 months old. This timeframe helps them calve within the first three weeks of the season, giving them a better chance of getting back in calf early and remaining in the herd[1, 2]. To achieve this timeframe, heifers need to reach puberty (i.e. sexual maturity) early enough to conceive during the first three weeks of the heifer mating period.

KEY POINTS

- Puberty is blocked at the brain until a threshold liveweight (~50 percent of mature liveweight) is reached.
- Management factors during heifer rearing affect when this threshold liveweight is achieved and, therefore, the timing of puberty.
- Genetics also influence the timing of puberty, as puberty occurs at an earlier age and at a lighter threshold liveweight in heifers with a higher genetic merit for fertility.
- 'Age at puberty' may be a useful predictor trait to evaluate cow fertility earlier and more accurately.

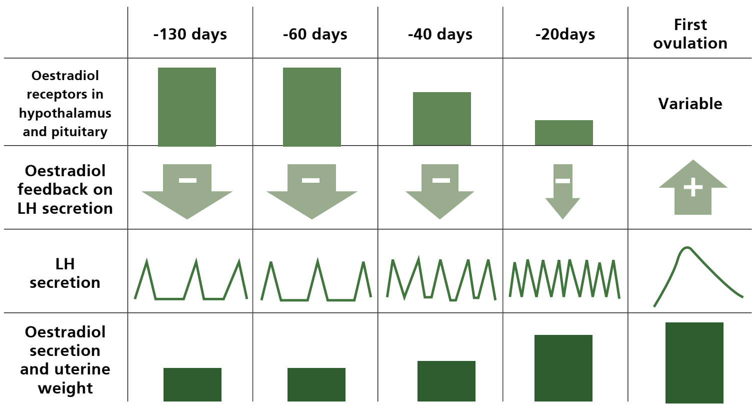
Removing the 'brain-block' to puberty

Puberty is triggered by signals from the brain to the ovaries. By eight months old, the hypothalamus and pituitary glands in a heifer's brain are developed sufficiently for the heifer to start cycling.

However, first heat and ovulation are 'blocked' because high numbers of receptors in the brain receive the ovary-produced sex hormone, oestradiol, as a strong negative feedback loop that prevents frequent pulses of luteinising hormone secretion required for ovulation *(Figure 1)*. Removal of this oestradiol 'brain-block' involves a complex hormone pathway that reduces the brain number of oestradiol receptors, and is influenced primarily by liveweight gain and genetics.

Hypothesis for endocrine control of puberty in heifers

Figure 1: Model for endocrine control of puberty (based on image from[3])



- 2-3 months before puberty is the pre-pubertal stage
- 1-2 months the peri-pubertal stage
- First ovulation is puberty
- LH = luteinising hormone

Liveweight gain drives the timing of puberty

It is well-established that heifers reach puberty by about half their expected mature liveweight. For example, a 450 kilogram (kg) mature liveweight cow will reach puberty by about 225kg. Hence, poor growth rates will delay the time to puberty[4].

To attain puberty before the start of mating at 13 to 15 months old, heifers should be reared to achieve liveweight targets of 30 percent, 60 percent and 90 percent of estimated mature liveweight at six months, 15 months (mating), and 22 months (pre-calving). Check out best practice growth and rearing information at **dairynz.co.nz/incalf**

A recent study of 10 commercial farms[4] revealed only 60 percent of heifers had reached puberty by the start of mating (range between farms was nine percent to 93 percent). Predictably, younger animals and those at a lower body condition score (BCS) below 4.5 units were at most risk of being pre-pubertal at mating start date. A similar trend was reported in an Irish study[1]; thus, heifers that are at least 14.5 months of age and 4.5 BCS units at the start of mating are more likely to have reached puberty.

The large percentage of pre-pubertal animals at mating start date on many farms indicates more attention is required to ensure heifers reach liveweight targets to prevent subsequent issues with reproductive performance.

Genetics also affect the timing of puberty

Genetics modify the effect of liveweight on the timing of puberty. Studies in beef cattle indicate approximately 30 to 40 percent of the variation in puberty onset between animals can be explained by their genetics[5, 6]. This moderate level of heritability is comparable to milk production traits and demonstrates the puberty trait will respond to selective breeding. Evidence in dairy cattle is limited, but recent work* supports a similar heritability[7].

Several studies indicate that animals with a greater proportion of North American Holstein-Friesian ancestry and/or a heavier liveweight Breeding Value (BV) take longer to reach puberty[8, 9, 10], putting them at a greater risk of not cycling before the start of mating.

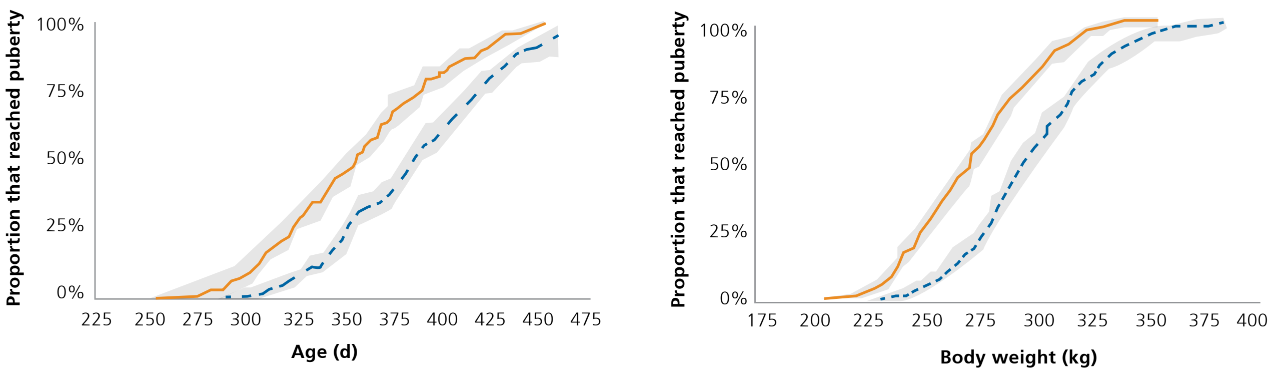
DairyNZ-led research* has recently demonstrated that heifers with a high Fertility BV (+5 percent) reached puberty 21 days earlier than those with a low Fertility BV (-5 percent), which meant they were 25kg lighter and at a lower percentage of mature liveweight (51 vs. 55 percent)[11] *(Figure 2)*. These groups grew at the same rate and did not differ in other traits.

These results indicate the oestradiol 'brain-block' was removed earlier in genetically fertile animals; consequently, 93 percent of high Fertility BV heifers but only 76 percent of low Fertility BV heifers reached puberty by the start of mating.

"MORE ATTENTION IS REQUIRED TO ENSURE HEIFERS REACH LIVEWEIGHT TARGETS TO PREVENT SUBSEQUENT ISSUES WITH REPRODUCTIVE PERFORMANCE."

A heifer mob being brought in for weighing.

Figure 2: The proportions of high (+5) and low (-5) Fertility BV heifers that had reached puberty at each age and liveweight (based on image from[11] and also from DairyNZ-led research*)



- High Fertility BV (solid line)
- Low Fertility BV (dashed line)
- Grey shading represents 95% confidence intervals

Puberty as a predictor trait of genetic merit for fertility

The earlier onset of puberty in high Fertility BV heifers indicates it could be a useful predictor trait for cow fertility in genetic evaluation. Earlier information would also be available on a sire's offspring than calving- and mating-focused cow fertility traits.

Puberty also appears to be a better genetic indicator of subsequent lifetime fertility than heifer in-calf rates, which don't appear to have such a strong genetic relationship to future fertility[2].

Further DairyNZ-led research* now underway will determine the genetic relationship between puberty and cow fertility traits using several thousand animals, while ensuring earlier onset of puberty doesn't compromise genetic gain in other economically important traits (e.g. milk production) that make up Breeding Worth (BW).

Improving the rate of genetic gain in fertility

Although fertility is a low-heritability trait, genetics will influence a cow's lifetime reproductive performance. The overall variation in reproductive performance among animals is very high, meaning the genetic contribution is still well worth capturing through selective breeding.

The Fertility BV is currently estimated using routinely recorded calving and mating traits:

- PM21 (inseminated within 21 days of planned start of mating in lactation 1, 2 and 3).
- CR42 (calving rate in the first 42 days after planned start of calving in lactation 2, 3 and 4).

Although these are robust values, they don't fully describe the genetic variation in the fertility trait.

It is hoped that the moderately heritable 'age at puberty' trait will allow us to evaluate cow lifetime fertility earlier, and with increased precision, so the Fertility BV can better capture the genetic variation in this trait. The more genetic variation we can capture, the better the rate of genetic gain in fertility the sector can achieve.

** This research has been carried out under Pillars of a New Dairy System, which is funded by dairy farmers through DairyNZ and by the Ministry of Business, Innovation and Employment, with aligned core funding for fertility from AgResearch. Additional funding and resources provided by Fonterra, LIC and CRV Ambreed support this key science platform. For more information, see* **dairynz.co.nz/pillars**

Heifers reach puberty at about half their expected mature liveweight.

REFERENCES:

1. Archbold, H., L. Shalloo, E. Kennedy, K. Pierce, and F. Buckley. 2012. Influence of age, body weight and body condition score before mating start date on the pubertal rate of maiden Holstein–Friesian heifers and implications for subsequent cow performance and profitability. The Animal Consortium 6:1143-1151.
2. Pryce, J. E., B. L. Harris, and L. R. McNaughton. 2007. The genetic relationship between heifer and cow fertility. Pages 388-391 in Proceedings of the New Zealand Society of Animal Production. Wanaka, New Zealand.
3. Day, M. L., K. Imakawa, P. L. Wolfe, R. J. Kittock, and J. E. Kinder. 1987. Endocrine mechanisms of puberty in heifers. Role of hypothalamo-pituitary estradiol receptors in the negative feedback of estradiol on luteinizing hormone secretion. Biology of Reproduction 37:1054-1065.
4. McDougall, S., F. M. Rhodes, and C. W. Compton. 2013. Evaluation of three synchrony programs for pasture-based dairy heifers. Theriogenology 79:882-889.
5. Morris, C. A., and N. C. Amyes. 2010. Correlated responses following genetic selection to change in age at puberty in Angus cattle. Pages 202-205 in Proceedings of the New Zealand Society of Animal Production. Palmerston North, New Zealand.
6. Martin, L. C., J. S. Brinks, R. M. Bourdon, and L. V. Cundiff. 1992. Genetic effects on beef heifer puberty and subsequent reproduction. Journal of Animal Science 70:4006-4017.
7. Price, M. D., M. D. Camara, J. R. Bryant, S. Meier, and C. R. Burke. 2017. Genetic parameters of puberty estimated using two genetically divergent groups of Holstein-Friesian dairy heifers. Pages 529-532 in Proceedings of the Association for the Advancement of Animal Breeding and Genetics. Townsville, Queensland, Australia.
8. Garcia-Muniz, J. G. 1998. Studies of Holtein-Friesian Cattle bred for Heavy or Light Mature live weight. PhD. Massey University. Palmerston North, New Zealand.
9. Macdonald, K. A., L. R. McNaughton, G. A. Verkerk, J. W. Penno, L. J. Burton, D. P. Berry, P. J. Gore, J. A. Lancaster, and C. W. Holmes. 2007. A comparison of three strains of Holstein-Friesian cows grazed on pasture: growth, development, and puberty. Journal of Dairy Science 90:3993-4003.
10. McGrath, M. E., J. F. Mee, S. E. M. Snijders, and D. O'Callaghan. 2001. The effect of genotype on the onset of puberty and subsequent fertility in dairy heifers. M. G. Diskin (Ed.) Page 46 in Proceedings of the Agricultural Research Forum. Tullamore, Ireland.
11. Meier, S., B. Fisher, K. Eketone, L. R. McNaughton, P. R. Amer, P. Beatson, J. R. Bryant, K. G. Dodds, R. Spelman, J. R. Roche, and C. R. Burke. 2017. Calf and heifer development and the onset of puberty in dairy cows with divergence in genetic merit for fertility. Pages 205-210 in Proceedings of the New Zealand Society of Animal Production. Rotorua, New Zealand.

Using data for mastitis detection

People commonly use health and wellbeing gadgets: have you done your 10,000 steps today? Similar technologies are used to measure cow performance and behaviour, but how useful are these for detecting mastitis?

Nicole Steele, post-doctoral scientist, DairyNZ
Jane Lacy-Hulbert, animal and feed team leader, DairyNZ

Investing in sensors or wearable technologies isn't at the forefront of most dairy farmers' minds. While current technologies can provide regular measures of cow performance and/or behaviour, adoption rates are generally low. Automated detection of diseases such as mastitis is challenging, with systems limited in their ability to act as an early warning system. However, there is potential for effective, low-cost detection systems to have significant impacts on herd health and performance.

KEY POINTS

- Sensors can capture many measurements from every cow in the herd every day.
- Adoption of data-capture technologies on New Zealand dairy farms is generally low, especially for mastitis detection.
- Current mastitis detection systems leave room for improvement in either performance or cost.
- Advances in sensor technologies and incorporating data from multiple sensors may improve detection, leading to greater adoption rates.

Sensor technologies

Greater automation of dairy farm practices has been apparent in recent decades, reducing the reliance on labour and assisting large herd management. There's now an opportunity to collect enormous amounts of data using less expensive sensors. This provides the ability to tease out patterns, trends, and associations relating to individual cow milk production and activity over time.

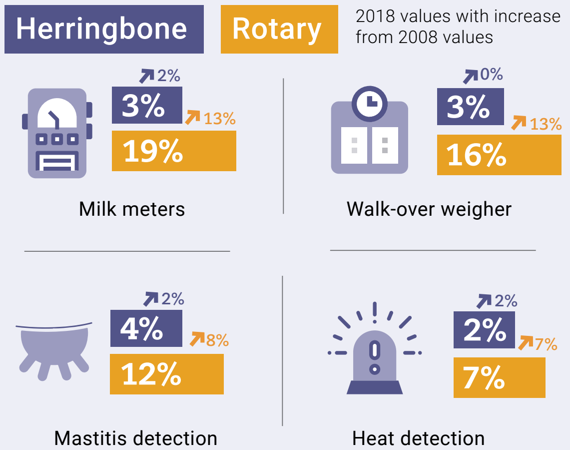
Farmers that have adopted sensor technologies typically see daily herd summaries and can be alerted to all sorts of changes, e.g. lists of cows that are in heat or suspected of having a health disorder. In-built alerts are based on algorithms designed by manufacturers, but all the data that lurks in the background could be put to greater use.

The limitations are no greater than in automated mastitis detection. Mastitis is a difficult disease to identify, and neither human nor sensor will be 100 percent accurate. The greatest challenge for common detection systems is the number of false alerts, which can cause farmers to lose trust in the system[1]. Additionally, mastitis alerts are limited in their ability to inform treatment decisions.

In this article, we consider a range of sensors that can collect data on an individual cow basis, and how these data relate to mastitis. The more we understand about the changes occurring before clinical mastitis is visually detected, the better armed we are to improve mastitis detection systems in the future.

Technology adoption on NZ dairy farms

According to DairyNZ's 2018 farmer survey, rotaries are more likely to have incorporated sensor technologies compared with herringbone sheds. These technologies include milk meters, walk-over weighers, and mastitis and heat detection systems. The level of adoption is also increasing at a faster rate for rotaries, though the uptake of data-capture technologies is low. Barriers to adoption in New Zealand include uncertainty of the benefits of a sensor, potential future improvements in current sensors which delay investment, suitability to seasonal and grazing systems, and other investment priorities[2].



Progression of mastitis infections

Mastitis is an inflammation of the mammary gland, usually occurring in response to bacteria that entered through the teat canal. Bacteria enter the ductal network, stick to the milk-producing cells (mammary epithelial cells), multiply, and release toxins (*Figure 1*). The immune system recognises bacteria and generates an inflammatory response. The combined efforts of bacteria and the immune system cause damage to mammary tissue, breaching the barrier that separates milk from blood within the mammary gland.

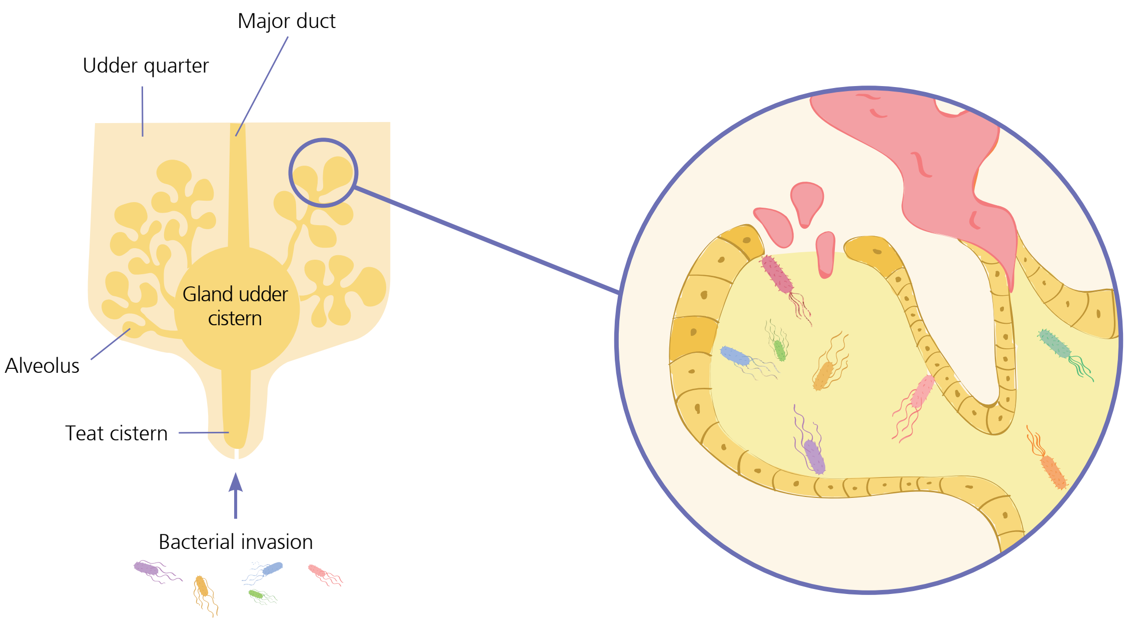
At this stage, the milker and various devices can detect changes in milk appearance, milk composition and sometimes cow behaviour. Each of these can be telling signs of inflammation, i.e. mastitis. The infection may be in a sub-clinical phase or pre-clinical phase, when mastitis cannot be detected by eye.

What causes mastitis?

With more than 140 different species of bacteria linked to mastitis in dairy cows[4], accurate and timely detection can be difficult. To assist with bacteria identification, we can broadly split bacteria into Gram-positive and Gram-negative bacteria (diagnosed by the Gram-stain procedure shown in *Figure 2*). By basing this on the way the bacteria are recognised by (and stimulate) the immune system, we can hone in on the differences between mastitis infections.

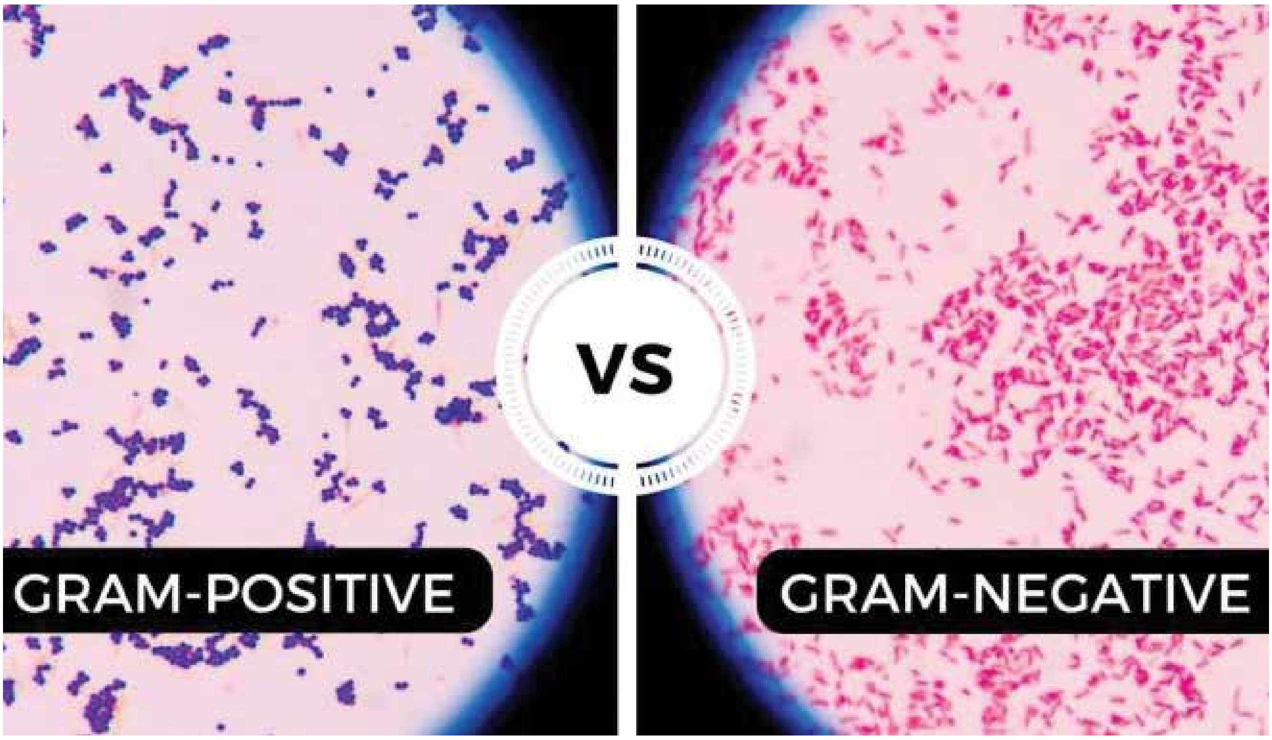
Infections due to Gram-positive bacteria might exist in a sub-clinical phase before progressing to a visible clinical infection. These typically respond well to antibiotic therapy

Figure 1: Mastitis development in an infected udder[3]



Left: *Structure of a mammary gland emphasising the entry point for bacteria.*
Inset on right: *Actions of bacteria and the immune system during mastitis, causing epithelial cell death and a breach in the blood/milk barrier.*

Figure 2: Comparison of Gram-positive (stains purple) and Gram-negative (stains pink) bacteria under the microscope[6]



(e.g. *Streptococcus uberis*). An exception is the Gram-positive contagious bacterium, *Staphylococcus aureus*, which can hide from the immune system and cause chronic infections, which often result in low cure rates when treated with antibiotics[5].

Gram-negative bacteria, such as *Escherichia coli*, commonly found in the environment and faeces, cause more problems in confinement systems. Most *E. coli* infections are short term with a rapid onset but with an equally rapid recovery (often without requiring antibiotic treatment).

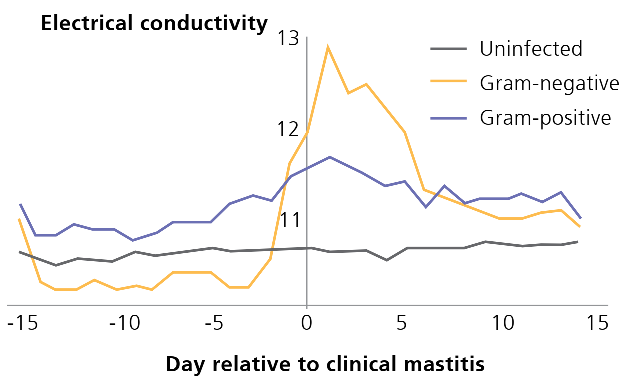
Sensor measures and mastitis

Sensors offer the ability to detect cows with mastitis without the physical task of regularly teat-stripping the herd, and systems currently do this, but the performance is variable. Sensors might also detect changes before clinical signs are present. If accurate, this provides opportunity for early intervention, if required. Sensors useful in modern dairy farming can be attached to the cow (i.e. worn on the body) or in the milking systems (often known as 'inline' or 'online'). Some inline sensors continuously measure milk from the beginning of milk flow to the end of milking, whereas an online sensor might sample a small amount of milk to measure the components of interest[7].

- **Somatic cell count (SCC)**

The SCC of milk increases during mastitis as the immune (somatic) cells are recruited from blood to milk to fight against the bacteria. To measure SCC online, somatic cells in a small sample of milk can either be counted directly (by a machine), or indirectly estimated, e.g. by measuring the viscosity or

Figure 3: Changes in electrical conductivity of uninfected and infected milk in the days before and after clinical mastitis detection on day 0 (Steele, unpublished).



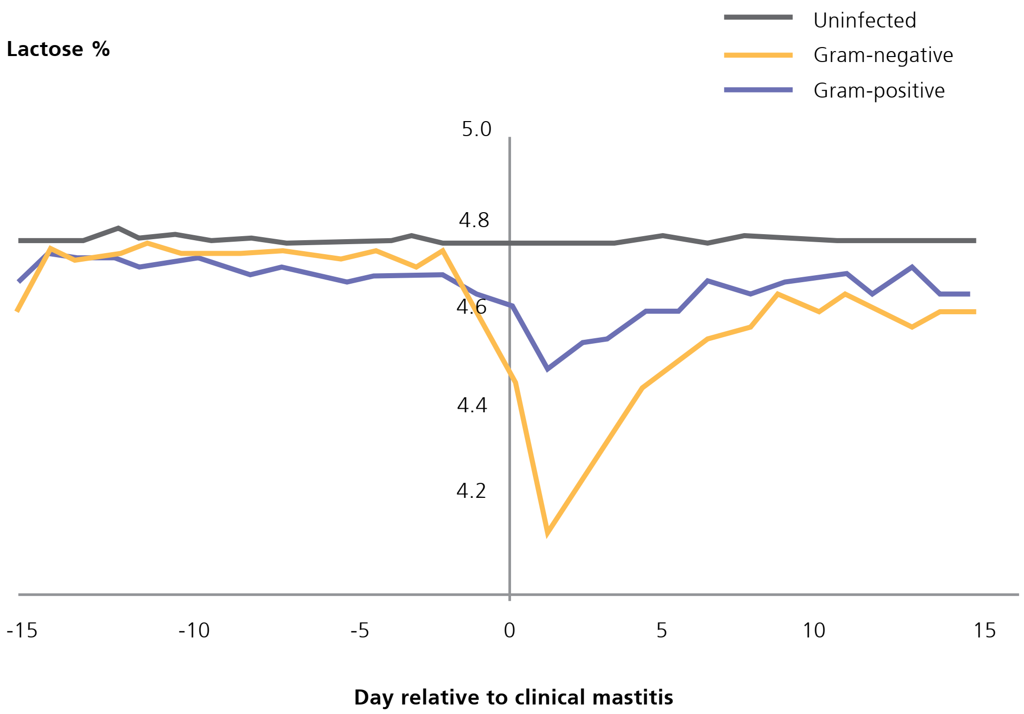
'gooeyness' of the milk. The latter requires addition of a detergent, causing the DNA from within somatic cells to clump together (it's an automated Rapid Mastitis Test).

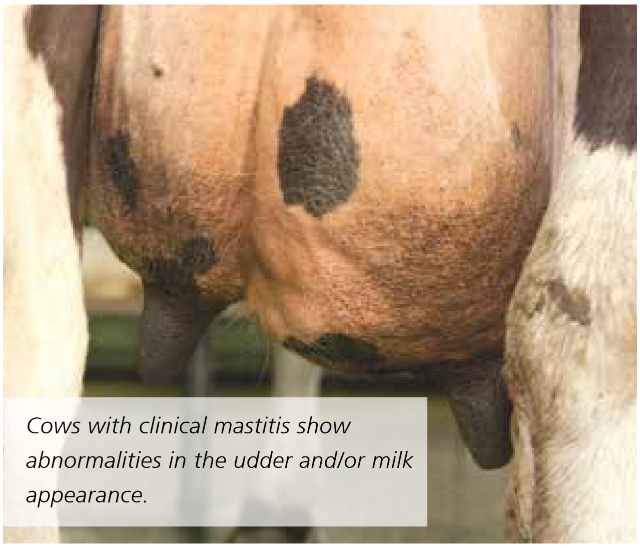
- **Electrical conductivity**

Electrical conductivity describes the ability of milk to carry an electric current. Milk from a healthy cow contains low concentrations of sodium and chloride ions, but when the blood/milk barrier is breached these ions can move from blood into the milk.

Because these ions carry a charge, they increase the

Figure 4: Changes in lactose percentage of uninfected and infected milk in the days before and after clinical mastitis detection on day 0 (Steele, unpublished).





Cows with clinical mastitis show abnormalities in the udder and/or milk appearance.

conductivity of the milk during mastitis. Since the 1940s, conductivity has been used in mastitis detection, firstly by hand-held meters, and later, through inline sensors[1]. Changes in conductivity can be observed four days before clinical mastitis is visually detected (*Figure 3,* previous page), although this depends on how severe the infection is and the type of bacteria responsible. However, the conductivity of milk is affected by factors other than mastitis, including temperature and milk fat content. On its own, conductivity has not provided a reliable indicator of mastitis, but performance is improved when comparing conductivity of quarters within a cow[8].

- **Milk yield and components**

Milk yield declines due to mastitis, but the size of the decline depends on the severity of the infection and the pathogen causing the infection, as well as the age of the cow and her stage of lactation[9]. Milk yield is a non-specific indicator of mastitis, because decreased milk production can occur for many reasons but it is useful when considered in combination with other mastitis-related parameters.

Inline sensors can measure milk lactose, protein, fat, and various enzymes. Lactose percentage declines in response to mastitis, whereas changes in protein and fat percent are not as clear-cut.

In a normally functioning mammary gland, the milk sugar (lactose) is present in milk at about 4.8 percent. During mastitis, lactose can escape from the milk as part of the blood/milk barrier breach. The ability of milk-producing cells to produce lactose

Milk appears visibly abnormal due to mastitis, with changes in colour and/or consistency.

is also compromised during mastitis due to reduced function, or even cell death. The decline in lactose during Gram-negative infections (e.g. *E. coli*) is more drastic than for Gram-positive infections (e.g. *Strep. uberis; Figure 4*). In contrast, lactose percentage in healthy cows remains stable over time, providing quite a good indicator of infection.

- **Cow behaviour**

As cows are prey animals, they use various behaviours to disguise sickness, especially pain. A cow will typically spend 10 to 12 hours lying per day. Changes in cows' time spent lying have been observed five days prior to clinical mastitis detection, varying within pathogen type and infection severity[10, 11].

Feeding behaviour and walking activity changes can also indicate disease. Considering behavioural changes in combination with milk composition changes will likely improve mastitis detection.

Future opportunities

Individual changes in milk-associated and behavioural parameters alone can be too vague to accurately indicate mastitis without an unacceptable number of false alerts. Combining data from different sensors can help form a much clearer picture and greater predictive ability. Eventually sensor systems could progress to the point where we can not only detect mastitis early, we can identify the bacteria type, improving treatment and other management decisions. Looking ahead, as sensor accuracy and data quality and recording improves, mastitis detection systems using sensors can only get better.

This focus is shared by the Pillars of a New Dairy System research programme. This programme is collecting activity data in a non-invasive manner to identify cows with sub-clinical diseases around the transition period. Ultimately, this research will contribute to greater lifetime productivity of cows.

Read about this research in *Inside Dairy* December 2018, page 18 at **dairynz.co.nz/inside-dairy** and find out more about the **dairynz.co.nz/pillars** programme.

Acknowledgements

This report describes some of Nicole Steele's PhD programme which was funded by New Zealand dairy farmers through DairyNZ in partnership with Virginia Tech (USA) and with financial assistance from the Virginia Agricultural Council.

REFERENCES:

1. Rutten, C. J., A. G. J. Velthuis, W. Steeneveld, and H. Hogeveen. 2013. Invited review: Sensors to support health management on dairy farms. Journal of Dairy Science 96(4):1928-1952.
2. Rutten, C. J., W. Steeneveld, A. G. J. M. Oude Lansink, and H. Hogeveen. 2018. Delaying investments in sensor technology: The rationality of dairy farmers' investment decisions illustrated within the framework of real options theory. Journal of Dairy Science 101:7650-7660.
3. Viguier, C., S. Arora, N. Gilmartin, K. Welbeck, and R. O'Kennedy. 2009. Mastitis detection: current trends and future perspectives. Trends in biotechnology 27(8):486-493.
4. Watts, J. L. 1988. Etiological agents of bovine mastitis. Veterinary Microbiology 16(1):41-66.
5. Barkema, H., M. Green, A. Bradley, and R. Zadoks. 2009. Invited review: The role of contagious disease in udder health. Journal of Dairy Science 92(10):4717-4729.
6. Karki, G. 2018. Difference between Gram positive and Gram negative bacteria. Online biology notes. Accessed March 29, 2019 from https://www.onlinebiologynotes.com/difference-between-gram-positive-and-gram-negative-bacteria/
7. Penry, J. F. 2018. Mastitis control in automatic milking systems. Veterinary Clinics of North America Food Animal Practice 34(3):439-456.
8. Nielen, M., H. Deluyker, Y. H. Schukken, and A. Brand. 1992. Electrical conductivity of milk: measurement, modifiers, and meta analysis of mastitis detection performance. Journal of Dairy Science 75(2):606-614.
9. Gröhn, Y. T., D. J. Wilson, R. N. Gonzalez, J. A. Hertl, H. Schulte, G. Bennett, and Y. H. Schukken. 2004. Effect of pathogen-specific clinical mastitis on milk yield in dairy cows. Journal of Dairy Science 87(10):3358-3374
10. Stangaferro, M. L., R. Wijma, L. S. Caixeta, M. A. Al-Abri, and J. O. Giordano. 2016. Use of rumination and activity monitoring for the identification of dairy cows with health disorders: Part II. Mastitis. Journal of Dairy Science 99(9):7411-7421.
11. King, M., S. Le Blanc, E. Pajor, T. Wright, and T. DeVries. 2018. Behavior and productivity of cows milked in automated systems before diagnosis of health disorders in early lactation. Journal of Dairy Science 101(5):4343-4356.

Disbudding: can we improve local anaesthesia for calves?

In this article, we examine an alternative method of administering local anaesthetic, which may be suitable for farmers to use if they disbud their own calves. This study found the alternative method was more reliable, faster-acting and at least as effective as the current method in preventing the behavioural signs of pain from disbudding.

Andrew Bates, Vetlife Scientific Ltd, Vetlife NZ
Jac McGowan, animal care specialist, DairyNZ

To prevent cattle from hurting people and other animals with their horns, farmers remove horn buds when calves are, ideally, two to four weeks old. Pain relief is a vital part of this disbudding process, both for animal welfare and future productivity. From October 1, 2019, all cattle must be provided with effective local anaesthesia when disbudded or dehorned. For most farmers, this won't require change, because their disbudding provider is already using local anaesthetic, or will start using it this October.

However, 15 percent of farmers currently disbud their own calves. These farmers have a variety of reasons for wanting to continue DIY disbudding. For example, for remote farms, the mileage costs of a disbudding provider can be significant. Others just enjoy working with their animals, disbudding a small group of calves each week with minimal disruption to the calves' routine. To continue disbudding their own calves after October 1, farmers will need to be trained by their veterinarian to administer a local anaesthetic block. For these farmers, it is essential that the local anaesthetic block is easy to learn and administer and results in fast, effective numbing of the horn buds.

This study looks at two methods of administering local anaesthetic prior to disbudding. The most common method of administering local anaesthetic prior to disbudding is the cornual nerve block (CNB). This is taught in veterinary schools and is typically the method veterinarians teach to non-veterinarians. An alternative method, called a bleb block, is used by some veterinary practices, but hadn't been formally validated in New Zealand.

From October 1, 2019, all cattle must be provided with effective local anaesthesia when disbudded or dehorned.

KEY POINTS

- Pain relief is essential for disbudding and improves recovery.
- Training is required before administering local anaesthetic.
- The most common method of administering local anaesthetic, via a cornual nerve block, requires patience, technical competence and practice to be consistently effective.
- A bleb block is an alternative method of achieving pain relief – it's quicker and consistently effective.
- Local anaesthetics available in New Zealand last about two hours, so a non-steroidal anti-inflammatory drug or long-acting topical anaesthetic can be used to extend pain control.

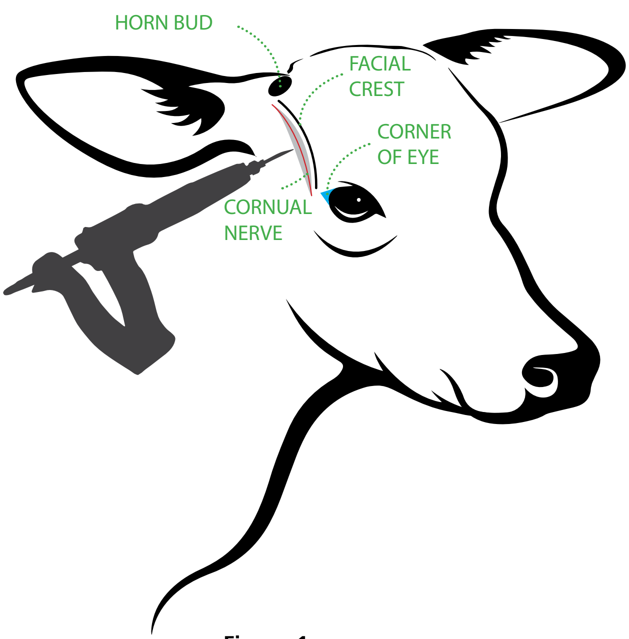


Figure 1

For a cornual nerve block, local anaesthetic is injected around the cornual nerve, in the groove below the facial crest, which runs from the eye to the horn bud.

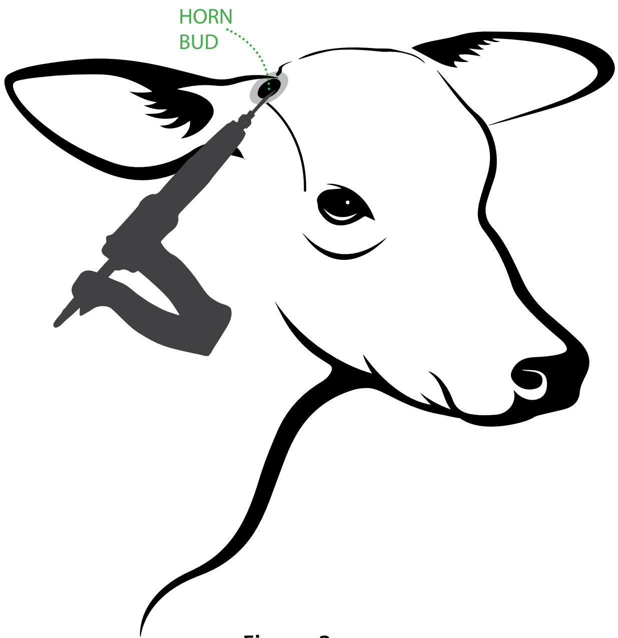


Figure 2

For a bleb block, local anaesthetic is injected directly over or beside the horn bud, so the local anaesthetic diffuses in a bubble or bleb over and around the back, front and sides of the horn bud.

The cornual nerve block

To administer the CNB, three to five millilitres (mL) of local anaesthetic is injected into the depression just behind, and to the side of, the calf's eyes (*Figure 1*). After the local anaesthetic is injected, it takes an average of 10 minutes for the local to spread to the nerve and numb the horn bud (ranges from five to 20 minutes[1, 2]).

CNB method issues

Evidence indicates it is difficult to get a reliable CNB for every calf[1, 3]. Rapid onset of action depends on how close the anaesthetic is injected to the branches of the cornual nerve that supply the horn bud. Delay or failure occurs when the anaesthetic is deposited in the muscle or further from the target nerve branches[6]. This happens for vets as well as non-vets, as it can be difficult to hit the right spot for every calf.

Extending pain relief beyond local anaesthetic

While local anaesthetic must be used in all disbudding and dehorning, it only numbs the horn bud for about two hours. Farmers wanting to do more than the minimum can also give a long-acting nonsteroidal anti-inflammatory drug (NSAID) or topical anaesthetic gel to reduce post-disbudding pain for up to 48 hours, depending on which drug is used. Using an NSAID can also increase milk consumption and growth of calves after disbudding[4, 5]. Full sedation can be used as a method of restraint, but also provides pain relief and reduces the stress of handling.

Where large groups of calves need to be disbudded at the same time, the necessary delay between giving the CNB and disbudding requires double handling of non-sedated, standing calves or multiple calf crates to avoid down-time. This can be impractical and cause extra stress to the animals. Time pressure can also lead to disbudding before the horn bud is completely numb, negating the welfare benefit of using local anaesthetic. Therefore, new options for local anaesthesia need to be explored.

The bleb block

This method involves injecting local anaesthetic directly under the loose skin over and around the horn bud. For small horn buds, a single injection (one mL) directly over the horn bud (*Figure 2,* previous page) is used. For larger buds attached to the underlying bone, two injections of one mL are required: one to the outside and one behind the bud, both as close as possible to the horn bud. This diffuses the anaesthetic in a bubble or 'bleb' over and around the horn bud.

The bleb block:

- uses smaller amounts of local anaesthetic (two to four mL per calf compared to six to 10 mL per calf for CNBs)
- makes the correct placement of the anaesthetic easier to achieve
- means anaesthesia is faster and more reliable, reducing time and cost
- is a quick and easy method to learn and use.

Validating its effectiveness

A study conducted according to New Zealand ethical requirements on two commercial dairy farms in Canterbury measured the following:

- The time required for the two block types (bleb vs. cornual nerve) to be effective.
- Any difference in the reaction of calves to the two methods of injection.
- Any differences in pain-related behaviour both during and after disbudding.

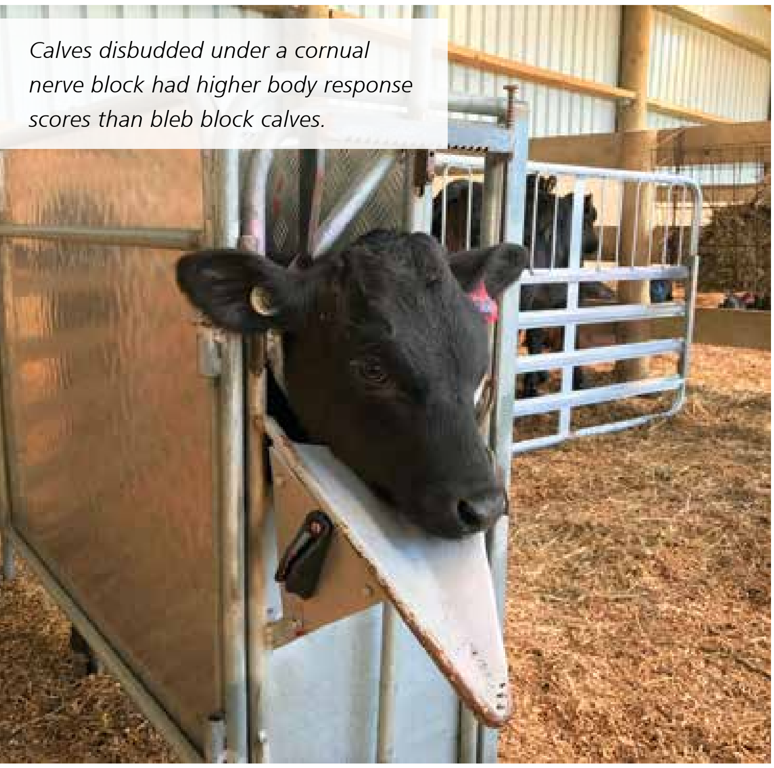
Twenty calves were negative control animals, handled and restrained identically to other calves but not injected or disbudded. Their responses represented the effect of handling alone.

Twenty different calves were injected with a local anaesthetic but not disbudded. Half of these received the CNB, and half received the bleb block. These animals were used to compare the effects of injecting anaesthetic by either method separate to the effects of handling.

Finally, 40 calves were given local anaesthesia and then disbudded. Twenty received the CNB and the other twenty received the bleb block before disbudding. These animals were used to compare the effect of disbudding following the two different block methods, separate from the effects of handling and injecting the local.

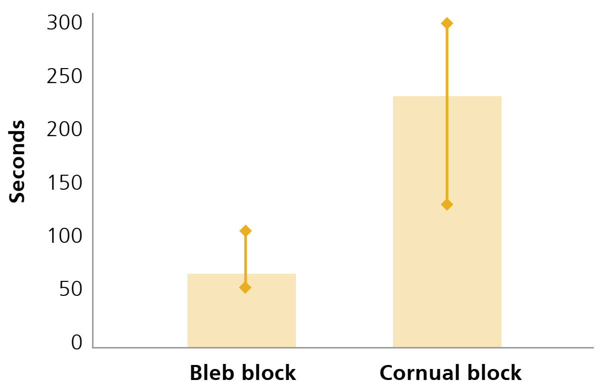
No calves were disbudded without the use of local anaesthetic, and all procedures were carried out by trained veterinary staff. No sedation was used, so the calves were standing.

Calves disbudded under a cornual nerve block had higher body response scores than bleb block calves.



Time to skin desensitisation

Figure 3: Median and range of time to skin desensitisation



Time to effectively block

Block effectiveness was assessed every 30 seconds by the response to three consecutive needle pricks over the horn bud. Calves were only disbudded if they showed no reaction to the needle pricks.

The bleb block worked much faster than CNB: median time to an effective block was 60 seconds for the bleb block compared with 225 seconds for the CNB. There was greater variability in the time for the CNB to be effective (120 to 300 seconds for CNB compared to 30 to 105 seconds for bleb; *Figure 3*).

Behaviour during disbudding

Body response during disbudding was classified on a scale of zero to three (*Table 1*). Non-disbudded control calves were restrained in the calf crate and their horn buds digitally massaged for 12 seconds to simulate 'sham' disbudding.

Disbudding method comparisons

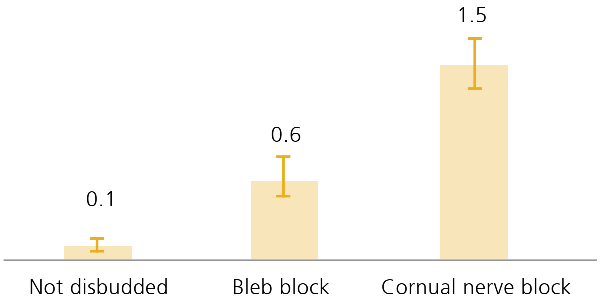
During disbudding, CNB calves had a much higher body response than bleb-blocked calves (1.2 for CNB calves compared to 0.6 for bleb-blocked calves; *Figure 4*). Since the

Table 1: Scale used to record body response during disbudding

Body reaction score	
0	No response, slight movement of body, tail wagging
1	Mild struggling, no foot stamping
2	Struggling with hind and front limbs
3	Massive struggling involving whole body

Body response to hot iron

Figure 4: Mean body response score for the treatment groups



Note: error bars represent 95 percent confidence intervals for the mean.

CNB calves were exposed to the same manipulations as bleb-blocked calves, their higher score indicates they experienced more pain during disbudding.

However, calves that were disbudded had higher body response scores than calves not disbudded, regardless of anaesthetic method. This indicates that, while the local anaesthetic should eliminate pain from disbudding, the calf may still react to having a person near its head, the smell/sound/heat of disbudding, or the pressure of the iron.

Disbudding methods and 'wait' times

Even though calves were only disbudded when they didn't react to the needle prick, CNB calves still had a body reaction score higher than the bleb-blocked calves (i.e. the horn bud was not adequately numb). Therefore, a more effective means of judging the degree of anaesthesia is needed. For a CNB, blink response while administering the block – and drooping of the eyelid after – may be better indicators that the anaesthetic is working, but require more experience to recognise[7].

Disbudded CNB calves also required a longer wait time

"CNB CALVES... REQUIRED A LONGER WAIT TIME BETWEEN INJECTION AND DISBUDDING."

Results indicated that disbudding (rather than time in the crate) caused the adverse body reaction, which suggests that the the CNB method of disbudding was less reliable at preventing pain.

between injection and disbudding, which may have created extra stress and contributed to the adverse body response for CNB calves during disbudding. However, CNB calves not disbudded had similar wait times and needle pricks, yet showed a significantly smaller body response. This indicates disbudding, rather than time in the crate, caused the adverse body reaction and, therefore, that CNB was less reliable at preventing pain.

Behaviour after disbudding

For the three hours after disbudding, behaviours associated with discomfort (e.g. head shaking, head scratching, head rubbing) and more positive behaviours (e.g. playing and self-grooming) were recorded[8].

In the three hours after disbudding, there was no significant

"FARMERS WANTING TO DO MORE THAN THE MINIMUM CAN ALSO GIVE A LONG-ACTING NONSTEROIDAL ANTI-INFLAMMATORY DRUG OR TOPICAL ANAESTHETIC GEL TO REDUCE POST-DISBUDDING PAIN ..."

The dairy sector is committed to ensuring the disbudding process is as pain-free as possible for calves.

difference in the behaviour of CNB disbudded calves and bleb-blocked disbudded calves. This indicates the level of pain control during this period was equivalent in both methods.

Time for farmers to consider the bleb block?

These results indicate the bleb block provided a more rapid, consistent and effective level of anaesthesia during disbudding compared with the CNB.

When injecting local for the CNB, it is impossible to know if the needle is in exactly the right place every time. For this reason, for the CNB, the minimum wait time (10 minutes) between administration of the CNB and disbudding is critical to allow the local anaesthetic to diffuse to the target. For the bleb block, we recommend a wait of two minutes between injection of local and hot iron application, to ensure effective anaesthesia.

The ease of administration and faster onset of the bleb block method might be preferable when large numbers of calves are being disbudded, or for farmers who disbud their own calves. Future work will establish training protocols and validate the effectiveness of the bleb block when administered by trained farmers.

Acknowledgements

This project was supported by a grant from AGMARDT NZ (A18005) and was a collaborative project between Vetlife NZ and AgResearch. The authors would like to acknowledge the input of B. Saldias, F. Chapple, P. Johnson, J. Singh, M. Sutherland, S. Dowling and the farmers and farm staff involved. All procedures were approved by the Ruakura Animal Ethics Committee. The full scientific text of the article is published within the Journal of Dairy Science[9].

REFERENCES:

1. Winder, C. B., S. J. LeBlanc, K. D. Lissemore, M. A. Godkin, and T. F. Duffield. 2018. Comparison of online, hands-on, and a combined approach for teaching cautery disbudding technique to dairy producers. Journal of Dairy Science 101(1): 840-849.
2. Stock, M. L., S. L. Baldridge, D. Griffin, and J. F. Coetzee. 2013. Bovine dehorning: assessing pain and providing analgesic management. Veterinary Clinics of North America: Food Animal Practice 29(1): 103-33.
3. Fierheller, E. E., N. A. Caulkett, D. B. Haley, D. Florence, and L. Doepel. 2012. Onset, duration and efficacy of four methods of local anesthesia of the horn bud in calves. Vet Anaesth Analg. 39(4): 431-5.
4. Bates, A. J., P. Eder, and R. A. Laven. 2015. Effect of analgesia and anti-inflammatory treatment on weight gain and milk intake of dairy calves after disbudding. New Zealand Veterinary Journal 63(3): 153-157.
5. Bates, A. J., R. A. Laven, F. Chapple, and D. S. Weeks. 2016. The effect of different combinations of local anaesthesia, sedative and non-steroidal anti-inflammatory drugs on daily growth rates of dairy calves after disbudding. New Zealand Veterinary Journal 64(5): 282-287.
6. Anderson, D. E., and M. A. Edmondson. 2013. Prevention and management of surgical pain in cattle.
7. Skarda, R. T. 1996. Local and regional anesthesia in ruminants and swine. Veterinary Clinics of North America: Food Animal Practice 12(3): 579-626.
8. Stafford, K .J., and D. J. Mellor. 2005. Dehorning and disbudding distress and its alleviation in calves. Veterinary Journal 169(3): 337-49.
9. Bates, A. J., Saldias, F. Chapple, A. P. Johnson, J. Singh, M. Sutherland, and S. Dowling. 2019. A new method of administering local anesthesia for calf disbudding: Findings from a comparative on-farm study in New Zealand. J. Dairy Sci. 102:2492–2506.

Comparing cow breed for profitable grazing systems

Cow breeds vary in their use of metabolisable energy for milk. This suggests that different cow breeds may offer farmers differing profit levels, as DairyNZ research intern Olivia Spaans explains.

In 2018, DairyNZ carried out research to help us better understand how cow breeds differ in their milk production, and use of metabolisable energy (ME) and pasture. Previously, comparative stocking rates (CSR) for profitable grazing dairy systems have been defined by accounting for the pasture production potential of the farm (tonnes of dry matter per hectare, or t DM/ha), the amount of feed imported from off-farm (t DM/ha), and cow liveweight (kilograms, or kg) to give a measure of kgs of cow liveweight/t of feed DM available[1].

However, CSR assumes no effect of cow genetics beyond liveweight. Also, there is increasing evidence of differences between breeds in their gross efficiency use of ME for milk production[2, 3].

To compare breed production and further understand this

Key results

- Annual per-ha pasture DM production and harvest were greater for the Jersey (J) farmlet, although J had 12 percent less pasture harvest and DM intake/cow than Holstein-Friesian (HF). This indicates HF has a greater drive to eat.
- As expected, HF produced more milk and a similar amount of protein/ha, and less milk fat than J.
- While J ate less DM/cow and produced a lower milk yield, it was able to utilise the pasture more efficiently to produce more milksolids/ha (fat and protein) and more milksolids/kg of liveweight than HF.

effect on profitability, DairyNZ last year analysed data from a production system experiment performed from 1990 to 1993. Funded by the DairyNZ Levy and the University of Waikato, this analysis aimed to determine whether Jersey (J) and Holstein-Friesian (HF) breeds had similar milk production. It also examined if they differed in their use of ME and amount of pasture eaten at the same liveweight per hectare with an expected CSR of 80, and no imported feed. Two farmlets were established, one for each breed. Biological data from the early 1990s experiment, and 2015 to 2017 financial data extracted from DairyNZ's DairyBase, were used to model the financial performance of each farmlet.

Implications for profitability

Economic analysis indicated that operating profit/ha was five percent greater for HF than J, although the gross farm revenue for J was $306/ha higher than HF. The analysis used a milk price of $0.55/kg ($4.41/kg milk fat and $8.02/kg protein), so J would have an even higher gross farm revenue advantage (+$167) under the current (2018/19) milk fat and protein values.

However, the lower operating profit was driven by greater farm operating expenses for J. This was due to the increased stock, feed, labour and other working expenses, reflecting the additional costs associated[4] with having more cows/ha for J to achieve the same CSR as HF.

Table 1: Comparison of cow breeds' use of ME (plus the effects of other variables) on grazing dairy system profitability and milk production

Breed	JER	HF
Stocking Rate (cows/ha)	3.6	3.0
Annual pasture yield (kg DM/ha)	17,267	16,273
Annual dry matter intake (kg/cow)	4,494	5,016
Milk yield (kg/ha)	11,510	13,816
Fat (kg/ha)	708	638
Protein (kg/ha)	484	486
Fat + protein (kg/ha)	1192	1124
Fat %	6.2	4.6
Protein %	4.2	3.5
ME for production (MJ/ha)	78,009	75,218
Total ME required (MJ/ha)	152,230	147,923
Milk price ($/kg MS)	5.88	5.97
Gross Farm Revenue ($/ha)	7522	7216
Total Dairy Operating Expenses ($/ha)	4186	3710
Dairy Operating Profit ($/ha)	3336	3505
Expenses ($/kg MS)	3.51	3.29

For more information about this research, please refer to the following publication:

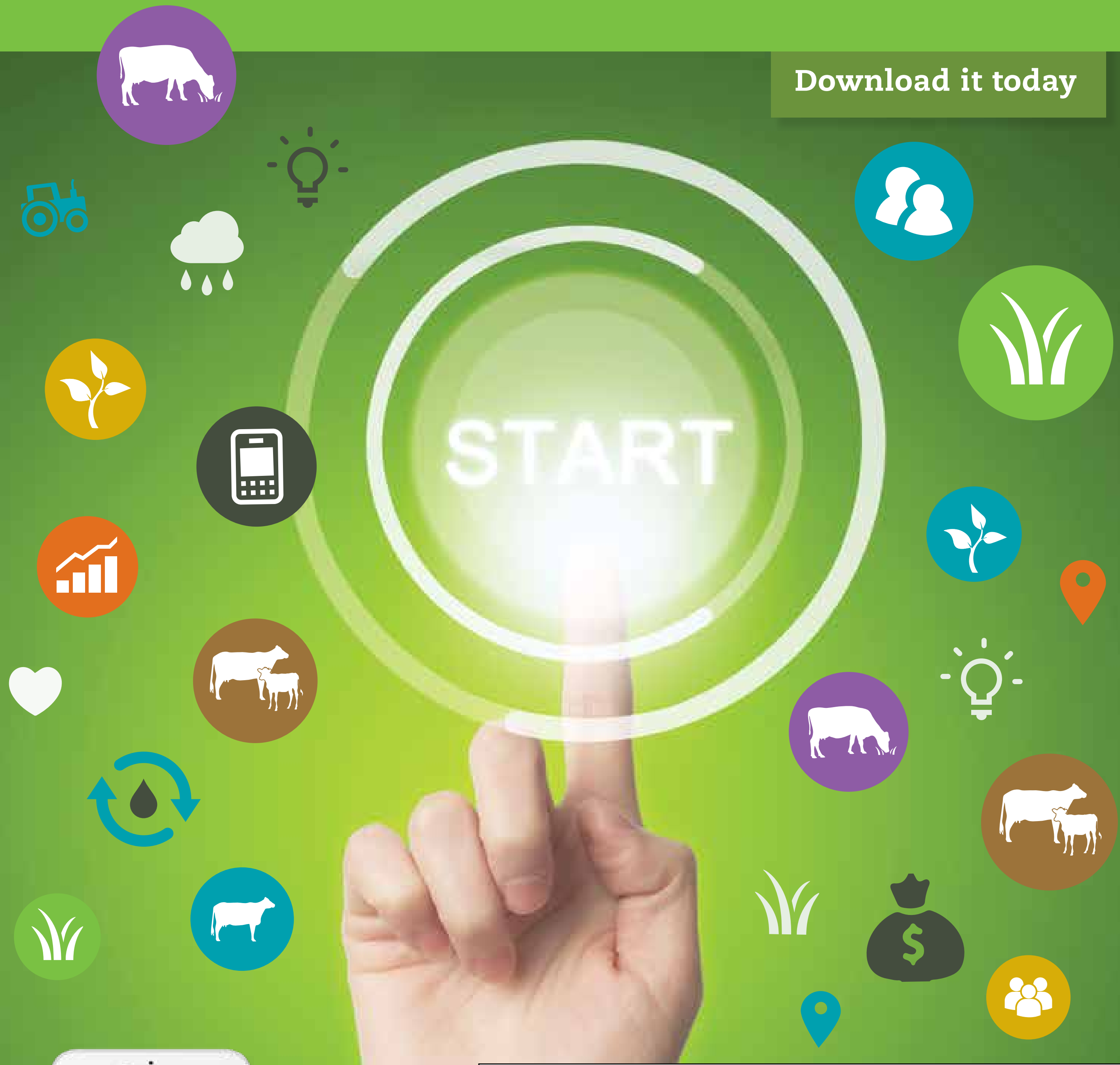
Spaans, O. K., K. A. Macdonald, J. A. S. Lancaster, A. M. Bryant, and J. R. Roche. 2018. Dairy cow breed interacts with stocking rate in temperate pasture-based dairy production systems. Journal of Dairy Science 101 (5): 4690-4702.

REFERENCES:

1. Macdonald, K. A., J. W. Penno, J. A. Lancaster, and J. R. Roche. 2008. Effect of stocking rate on pasture production, milk production, and reproduction of dairy cows in pasture-based systems. Journal of Dairy Science 91(5): 2151-2163. doi: 10.3168/jds.2007-0630.
2. Prendiville, R., K. M. Pierce, and F. Buckley. 2009. An evaluation of production efficiencies among lactating Holstein-Friesian, Jersey, and Jersey×Holstein-Friesian cows at pasture. Journal of Dairy Science 92(12), pp. 6176–6185. doi: 10.3168/jds.2009-2292.
3. Beecher, M., F. Buckley, S. M. Waters, T. M. Boland, D. Enriquez-Hidalgo, M. H. Deighton, M. O'Donovan, and E. Lewis. 2014. Gastrointestinal tract size, total-tract digestibility, and rumen microflora in different dairy cow genotypes. Journal of Dairy Science 97(6): 3906-3917. doi: 10.3168/jds.2013-7708.
4. Macdonald, K. A., D. Beca, J. W. Penno, J. A. S. Lancaster, and J. R. Roche. 2011. Short communication: Effect of stocking rate on the economics of pasture-based dairy farms. Journal of Dairy Science 94:2581–2586. doi:10.3168/jds.2010-3688.

DairyNZ Facts & Figures App

Download it today



New Zealand
Permit No. 174646
Permit

Sender: DairyNZ, Private Bag 3221, Hamilton 3240, NZ

Farm with the facts at your fingertips

Available for download from the App Store or Google Play.

DairyNZ