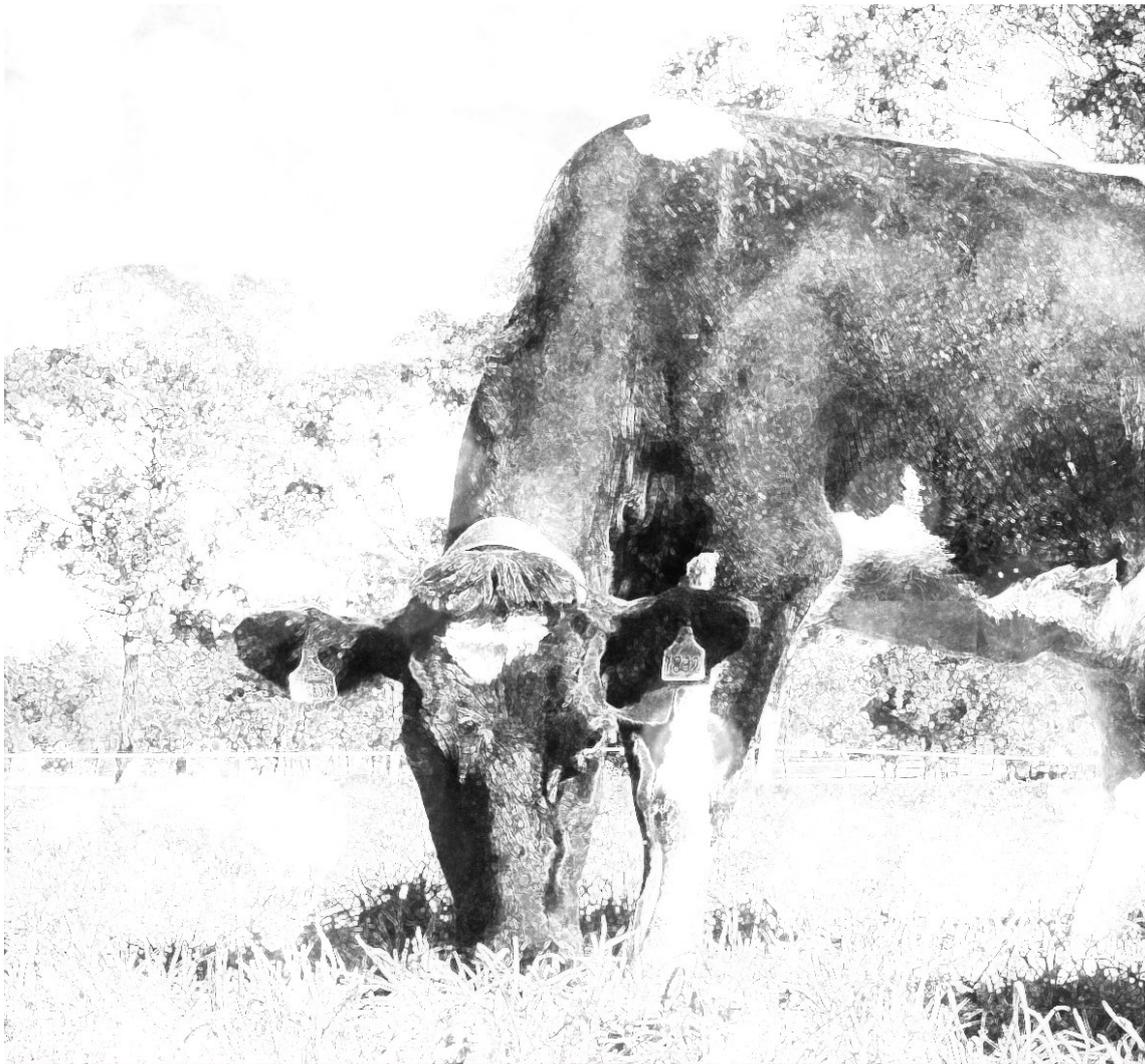




THE UNIVERSITY OF  
**SYDNEY**

## **Current Topics in Dairy Production**

Volume 22 July 26 and 27, 2017



**Dairy Research Foundation**

**2017 Symposium**

**MILC – More Income Led by Cows**

**Port Macquarie NSW**



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THE UNIVERSITY OF  
**SYDNEY**

**DAIRY RESEARCH FOUNDATION**

**CURRENT TOPICS IN DAIRY PRODUCTION**

**VOLUME 22**

**2017**

Compiled by Michelle Heward

Edited by Yani Garcia, Sherry Catt, Nicolas Lyons and Michelle Heward

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# WELCOME TO THE DAIRY RESEARCH FOUNDATION 2017 SYMPOSIUM

In 2017 we take the Dairy Research Foundation Symposium to the beautiful coastal destination of Port Macquarie in NSW!

The extremely positive response to the Symposium visiting different dairying regions of NSW has brought about the decision to take it on the road again in 2017.

We kick off again this year with our Industry day where our industry bodies come together to stage their meetings, forums and updates. We welcome the collaboration of NSW Farmers, Dairy Connect and Dairy NSW whom are all participating again this year.

For 2017 we have another stellar line-up of speakers, headed by Josè Santos from Florida University. Josè is across all of the latest research into reproductive performance of the modern cow. He will bring us up to speed with his research findings and industry learnings in relation to farmers generating the most successful reproductive outcomes.

Farm Day will take us to 'Hastings Park' - the property of Leo & Sue and Luke & Megan Cleary. Attendees will not be disappointed by the array of things to see at 'Hastings Park'. The family is very well respected within the industry and are top operators in their field.

In keeping with tradition, the real focus of the Farm Day will be our Emerging Scientists - the best and brightest of our next generation researchers. Bring your voting hats as they vie for first place in the 2017 DRF Emerging Scientist Award. Their challenge is to inform you of the impact that their research can have at a farm or industry level.

We look forward to catching up with our loyal attendees but we also want to extend a welcome invitation to any farmers who haven't previously attended. Be assured you will be welcomed with open arms – we truly believe that you will walk away from the event with new contacts, ideas to implement in your own business, a new spring in your step and stimulated passion for what you do.

We look forward to welcoming you to Port Macquarie in July 2017.



Associate Professor Kendra Kerrisk

**Chair of Symposium Organising Committee**

## DAIRY RESEARCH FOUNDATION 2017 SYMPOSIUM ORGANISING COMMITTEE

### Chair

Kendra Kerrisk      *University of Sydney*

### Committee

|                  |  |               |                        |
|------------------|--|---------------|------------------------|
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| Greg Duncan      | <i>Dairy NSW</i>                       | Sergio Garcia | <i>USYD/DRF</i>        |
| Kerry Kempton    | <i>NSW DPI</i>                         | Sheena Carter | <i>Dairy Australia</i> |
| Leo Cleary       | <i>Farmer Member</i>                   | Tara Wolfson  | <i>EJM Events</i>      |
| Michael Campbell | <i>Charles Sturt University</i>        | Mike Jeffery  | <i>Norco</i>           |
| Michael Perich   | <i>Leppington Pastoral<br/>Company</i> | Wayne Clarke  | <i>Farmer Member</i>   |

## THE EMERGING DAIRY SCIENTISTS' PROGRAM

The Dairy Research Foundation is pleased to showcase the talents of Australia's emerging dairy scientists at the 2017 event.

Their presentations are the focus of our Field Day program and all have been paired with a senior consultant or scientist to create a highly interactive series of discussions.

The intent behind this encounter is to offer an opportunity for professional development for these emerging scientists.

Here we introduce them to and assimilate them with our industry. The program is in the form of a competition, where we ask you, the audience, to assess the quality, relevance and interest of each presentation – with the audience scores combined to determine a winner. This is announced at the conclusion of the Field Day.

The program clearly identifies those competing in the Emerging Scientists' Program – and we encourage your full participation which will do much towards encouraging our next generation of dairy scientists.

# DAIRY RESEARCH FOUNDATION 2017 SYMPOSIUM SPONSORS

The Dairy Research Foundation would like to acknowledge and sincerely thank the following organisations and companies for their support.

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# IMPROVING DAIRY COW REPRODUCTION WHILE MAINTAINING HIGH MILK PRODUCTION

**José Eduardo P. Santos**

*Department of Animal Sciences*

*University of Florida, Gainesville, FL USA*

## **Abstract**

*Genetic selection with emphasis only on yields of milk and milk components until the mid -1990's has been blamed for a large component of the historical decline in dairy cattle fertility in the USA. It is known that reproductive traits are genetically negatively correlated with production traits and emphasis on yields of milk and milk components probably increased the pool of genes that are deleterious for proper reproduction. Epidemiological data summarized by Butler (1998) clearly demonstrated the inverse phenotypic relationship between milk yield and pregnancy per artificial insemination (AI) in dairy herds in the state of New York.*

*Nevertheless, combined efforts in management, nutrition, peripartum health, reproductive management, and, more recently, genetic selection for health and fertility traits have changed this picture of continued decline in reproductive performance in the US dairy cow herd. In fact, measures of reproduction have consistently improved in the last 16 years. For instance, in the Holstein breed, which comprises more than 90% of all dairy cattle in the USA, the average calving interval has declined an average of 2.7 days per year in the last 10 years, from approximately 423 days in 2005 to 401 days in 2014. Such a reduction in calving interval implies that the average days open (calving to pregnancy interval) for the USA dairy herd is now at approximately 123 days, at the same time that mean milk production continues to increase at approximately 1.3% per year without any signs of slowing down.*

## **Reproduction Has a Major Economic Impact on a Dairy Farm**

Reproduction has numerous impacts on the economy of a dairy farm, from altering decisions on culling to improving genetic gain and milk production. In most farms in the US, sale of milk represents almost 90% of the gross income generated in a farm (Santos *et al.*, 2010); therefore, it is not a surprise that most dairy producers devote attention to improving reproductive performance because they understand timely pregnancy influences the milk yield during the productive life of a cow. The general premise is that reducing calving interval by improving reproductive performance will reduce the days in milk of the herd and increase the proportion of cows in the more productive portion of the lactation curve, thereby reducing the number of cows with advanced lactation when production is typically less. This strategy becomes even more important when persistence of lactation is less.

Ribeiro *et al.* (2012) illustrated the importance of shortening calving interval by reducing days open in high-producing dairy cows. The authors showed that income over feed costs declines as days in milk increases, and this response was independent of milk production per cow and scenarios of feed cost per kg of dry matter, unless major changes in lactation persistence occurred. For instance, for a herd producing 12,500 kg of milk/cow in 305 days of lactation (mean of 41 kg of milk/cow/day), the authors showed that reducing the calving interval from 440 to 377 days would represent an increase of 7% in the income over feed cost an additional 498 kg of milk per cow per year (Ribeiro *et al.*, 2012).

When the authors modeled the same change in calving interval in a herd averaging 9,000 kg of milk/cow in 305 days of lactation (i.e. 29.5 kg of milk/cow/day), the reduction in same 63 days of

calving interval would represent an increase of 8% in the income over feed cost and an additional 366 kg of milk/cow/year. It is interesting to note that the impact of reproduction relative to influencing milk per day of calving interval is dependent on the persistence of lactation. Less productive, less persistent cows suffer more dramatically in terms of economic loss if pregnancy is not obtained at the proper time postpartum. Thus, the lower the milk production persistency the higher is the daily milk increment with improvements in reproductive performance.

Reproduction also influences culling and replacement policies and herds with improved reproductive performance have more flexibility in those decisions because of increased abundance of replacement heifers and pregnant cows. Such changes allow managers to take programmed decisions based on economic aspects rather than biological considerations.

Reproductive inefficiency increases cost per pregnancy, increases retention of low-producing cows because of their pregnancy status, and reduces the number of replacements, which diminishes the genetic gains of the herd. Maintaining the same replacement pressure when reproduction is poor becomes, in many cases, costly and risky as it requires purchase of heifers that may be of lower genetic merit and results in breaks of biosecurity.

Given a specific type of dairy cow and production system, there is an optimal interval from calving to pregnancy at which profitability is maximized. Cows not pregnant beyond this optimal time become economically less attractive. The cost of a day open varies from \$0 at the optimal day postpartum at pregnancy to as much as \$6.00 depending on the circumstances (De Vries, 2011). Therefore, most producers aim to take advantage of this optimum window of when cows should become pregnant.

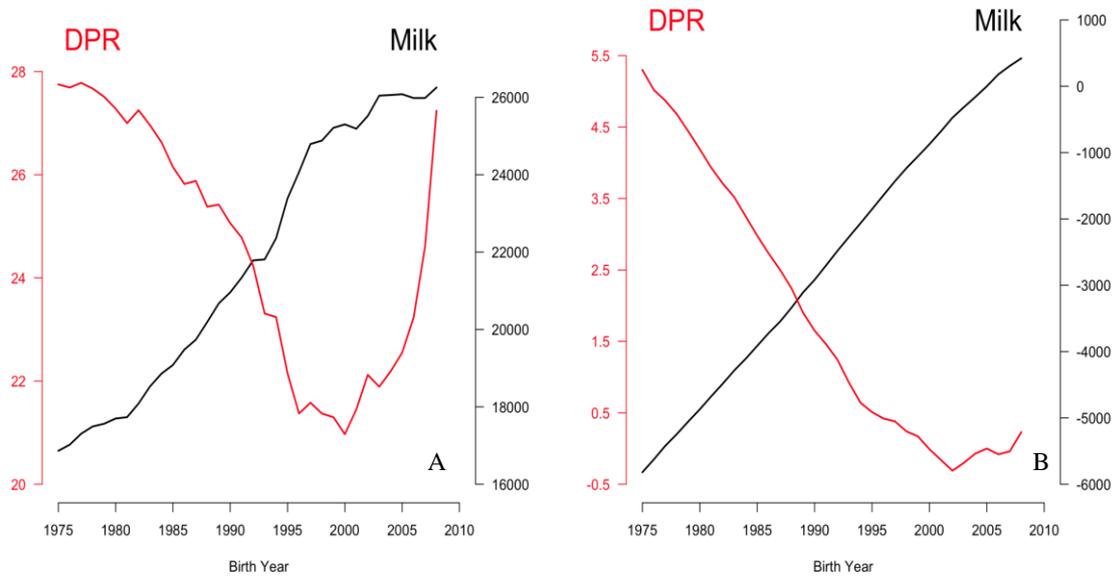
Furthermore, in addition to the cost of a day open, there is substantial value in a new pregnancy. The value of a new pregnancy is greater for low-producing cows at early stages of lactation and the peak is less and earlier than that for high-producing cows (De Vries, 2011). On the other hand, pregnancy loss, which typically affects 12 to 18% of the pregnancies after 32 days of gestation (Santos *et al.*, 2004), is extremely expensive, and follows similar patterns and increases as lactation progresses or stage of gestation increases.

The average value of a new pregnancy for a Holstein cow in the United States has been estimated at \$278, whereas the cost of a pregnancy loss was \$555 (De Vries, 2006).

### **Current Status of Reproduction in the US Lactating Herd**

Historically, most reports in the literature describe reproductive performance in lactating dairy cows as declining in the US. In fact, Butler (1998) demonstrated the inverse phenotypic relationship between milk yield and pregnancy per AI (P/AI) in dairy herds in the state of New York from 1951 to 1996. At the same time, reproductive performance in growing heifers have not been reported as declining indicating that whatever the mechanisms for less fertility, they probably were observed only once lactation was initiated.

Reports from the United States Department of Agriculture indicate that both phenotypic and genotypic daughter fertility hit their bottom in the early 2000's and, since then, an upward trend has begun, with phenotypic gains observed much faster than genotypic gains, which is not surprising given the low heritability for daughter fertility, only 4%. In fact, phenotypic daughter fertility today is compatible with values observed in the 1980's (Figure 1A).



**Figure 1. Phenotypic (A) and genetic (B) trends for daughter fertility represented by daughter pregnancy rate (DPR) and milk yield in pounds per year according to year of birth. The left Y axis represents DPR calculated as the proportion (%) of eligible cows pregnant every 21-d past 60 days in milk. The right Y axis represents milk yield in pounds per year. It is clear that daughter fertility has improved starting in early to mid-2000's and the phenotypic gain has been faster than the genotypic gain.**

The key metrics used to evaluate reproduction in the USA is pregnancy rate. Pregnancy rate is the rate at which eligible cows become pregnant and it is typically measured in intervals of 21-d. An eligible cow is a cow that passed the voluntary waiting period, she is not pregnant, and the producer wants to get her pregnant. For instance, imagine that the voluntary waiting period for a herd of 100 cows is 50 days in milk. Every 21-d, a non-pregnant cow is expected to return to estrus and can potentially be inseminated.

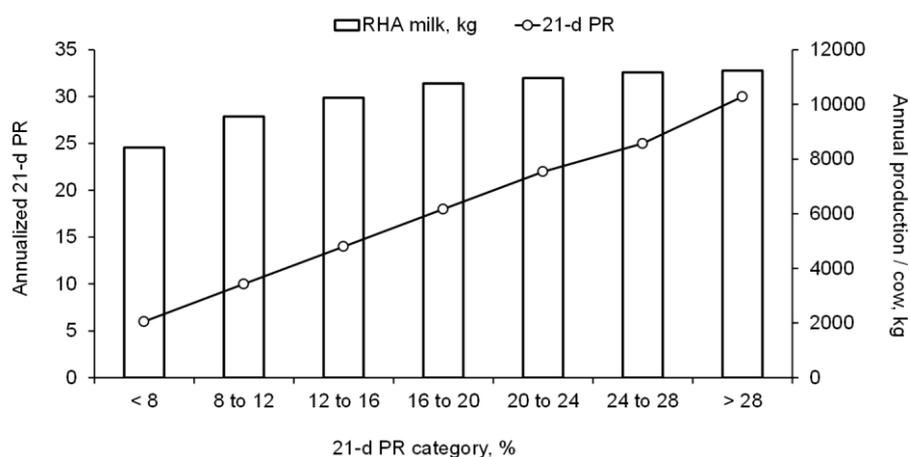
Whether she shows estrus or not is a function of her biology, the environment, and the ability of the producer to detect the cow to be inseminated. A cow that is not pregnant by 150 days in milk has had multiple 21-d intervals and has contributed multiple times with the calculation of pregnancy rate. Now, let's assume that this herd is able to inseminate 65% of the eligible cows in the first 21-d past the voluntary waiting period and P/AI in the window of time is 38%. After that, the herd is able to inseminate 45 to 55% of the eligible cows with P/AI between 30 and 33% (Table 1).

**Table 1. Example of a typical dairy herd relative to reproductive performance**

| Days in milk | Eligible cow | Inseminated | Pregnant | Open | IR    | P/AI  | 21-d PR |
|--------------|--------------|-------------|----------|------|-------|-------|---------|
| 50 to 70     | 100          | 65          | 25       | 75   | 65.0% | 38.0% | 24.7%   |
| 71 to 91     | 75           | 36          | 11       | 64   | 48.0% | 30.0% | 14.4%   |
| 92 to 112    | 64           | 35          | 11       | 54   | 54.0% | 31.0% | 16.7%   |
| 113 to 133   | 54           | 26          | 9        | 45   | 48.0% | 33.0% | 15.8%   |
| 134 to 154   | 45           | 23          | 7        | 39   | 52.0% | 28.0% | 14.6%   |
| 155 to 175   | 39           | 19          | 6        | 33   | 48.0% | 30.0% | 14.4%   |
| 176 to 196   | 33           | 15          | 4        | 29   | 46.0% | 27.0% | 12.4%   |
| Total        | 410          | 219         | 71       | 339  | 53.4% | 32.5% | 17.3%   |

IR = insemination rate; P/AI = pregnancy per artificial insemination; 21-d PR = 21-d cycle pregnancy rate

This example herd has a mean insemination rate (proxy for estrous detection rate) of 53.4%, mean P/AI of 32.5% and mean 21-d cycle pregnancy rate of 17.3%. These results represent the average values for the US industry today. Nevertheless, a few thousand herds today, out of the 46,000 dairy farms, achieve 21-d insemination rates of 65 to 70%, P/AI of 45 to 50%, and are capable of maintaining 21-d cycle pregnancy rate above 28%. In fact, herds with the highest 21-d cycle pregnancy rate were also herds with greater milk production per cow per year (Figure 2).



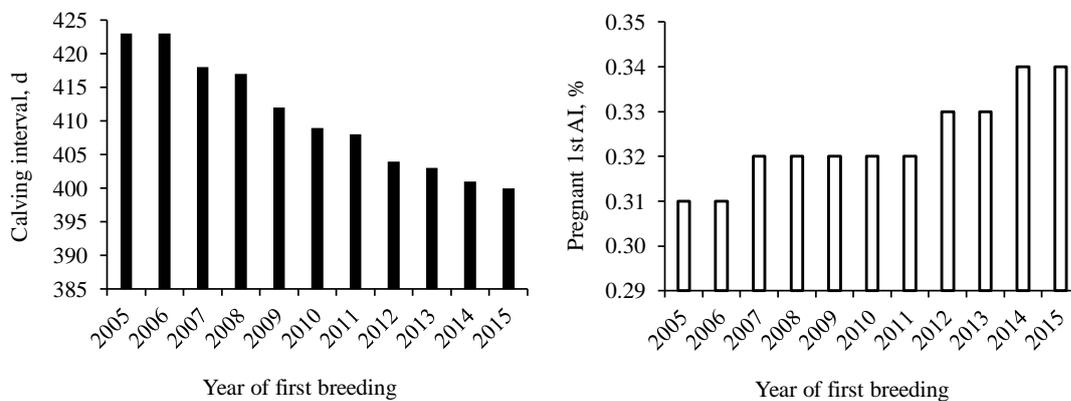
Source : DRMS, DairyMetrics, April 26<sup>th</sup>, 2011

**Figure 2. Rolling herd average (RHA) for milk yield (kg/cow/year) and 21-d cycle pregnancy rate (21-d PR) for herds in the eastern USA categorized according 21-d PR. Herds with greater 21-d PR also had greater milk production. Source DRMS, Dairy Metrics, USA.**

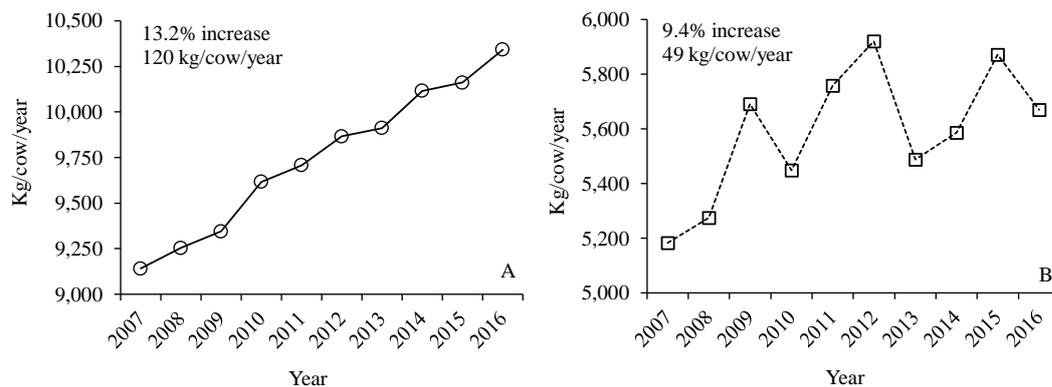
Although on farm calculation of pregnancy rate is based on a proportion of all potential pregnancies that are obtained as depicted in Table 1, the national herd uses the following formula to calculate pregnancy rate:

$$\text{Pregnancy rate} = 21 / (\text{days open} - \text{voluntary waiting period} + 11)$$

In which the voluntary waiting period is set at 60 days in milk and the +11 factor in the formula adjusts to the middle day of the 21-day cycle so that cows that conceive during the first cycle receive 100% credit on average. Using this formula, which is based on days open (interval from calving to pregnancy), one can see how much progress has been made in recent years (Figure 3). In fact, calving interval has declined from 423 days in 2005 to 400 days in 2015 at the same time that pregnancy at first AI has climbed from 31 to 34% in the Holstein breed (Figure 3). Similar positive changes have been observed in all other dairy breeds. Therefore, it is clear that major progress has been made in dairy cow reproduction, at the same time that milk production per cow continues to increase at a steady pace of 120 kg/cow/year (Figure 4A). The changes observed in the last 10 years represent a 13.2% increase in production per cow in the USA, with increments also observed for the Australian dairy industry, a 9.4% increase in the same period (Figure 4B).



**Figure 3. Trends in reproductive performance in the Holstein breed in the US. Data extracted from the Council on Dairy Cattle Breeding and includes 9.3 million records for calving interval and 16.8 million records for pregnancy at first insemination between 2005 and 2015.**



**Figure 4. Changes in milk production per cow per year in the USA (A) and Australia (B) from 2007 to 2015. Sources, US Department of Agriculture and Dairy Australia. The changes observed in the last 10 years represent a 13.2% increase in production per cow in the USA and 9.4% increase in production per cow in Australia.**

## **Peripartum Health is Critical for Reproduction**

Many of the diseases that affect dairy cattle either in confinement or pasture-based systems typically occur in the first two months of lactation, before the first postpartum insemination (Ribeiro *et al.*, 2006). The increased susceptibility to metabolic and infectious disease with parturition and the onset of lactation poses a major challenge to reproduction. Cows that suffer from uterine, mammary and metabolic diseases have delayed resumption of postpartum ovulation, compromised fertilization and pre- and peri-implantation embryo development, compromised pregnancy, and increased pregnancy loss (Ribeiro *et al.*, 2016). Therefore, it is imperative that health programs be implemented in order to minimize the negative impacts of diseases on reproduction. Such interventions include, but are not limited to, improving transition cow management and grouping, proper dietary formulation to prevent peri-parturient diseases associated with intermediary and mineral metabolism, strategies for reducing calving-related disorders, and methods to prevent mastitis and lameness.

The typical transition cow program in USA dairy herds usually follow a pattern from dry off at approximately 225 to 230 days of gestation to 30 days in lactation that includes dry-off protocols, preventative hoof trimming, vaccination program to protect the cow and the newborn calf, proper housing for proper comfort including protection against heat stress, feeding diets that minimize the risk of metabolic diseases postpartum such as hypocalcemia and ketosis, and postpartum care with programs for identification and treatment of problem cows. Despite this effort, incidence of diseases remain high and future efforts are likely to focus on short-term strategies to minimize the risk of common diseases as well as long-term efforts in genetic selection to minimize genotypes with increased risk for disease development.

## **Nutrition Influences Peripartum Health and Reproductive Performance**

An important issue with high-producing dairy cows is that they have been genetically selected to partition nutrients to favor milk yield at the expense of body reserves even during periods when nutrient intake is less than ideal, such as during early lactation. Dairy cows that experience excessive loss of body condition can have delayed days to first estrus and ovulation which can magnify postpartum infertility. The underlying cause for this delay in return to ovulatory cycles seems to be associated with metabolic signals and regulatory hormones originated from the gut such as insulin and insulin-like growth factor 1. These two metabolic hormones are some of the links between nutritional status of the cow with important reproductive hormones that control reproduction in cattle.

Diet formulation incorporates concepts not only to optimize yields of milk and milk components, but also to improve reproductive performance. An example is to incorporate dietary fats in diets of dairy cows, which has been shown to not only improve production, but also reproduction (Rodney *et al.*, 2015). In addition, diet formulation aims to minimize the losses of body condition in early lactation by manipulating carbohydrate fractions, improving dry matter intake, and supplying sufficient amounts of protein (amino acids) according to level of production. Perhaps, more important that diet formulation per se is feeding management. Provision of adequate feed bunk space, having feed available 23 to 24-h a day, avoid competition, assuring consistency in feed delivery, are all measures put in place to give cows the opportunity to eat as much as they desire when intake is insufficient to meet the needs for production.

## **Rationale Implementation of Reproductive Programs**

One of the major advancements in reproduction in the last 20 years has been the rationale implementation of reproductive programs in dairy herds. Until recently, veterinarians and producers applied reproductive management in a reactive manner; however, in recent years, reproductive programs have taken a slightly different approach. The goal is to be proactive and work with groups of cows. In most cases, the focus is to increase the rate at which eligible cows become pregnant and, for that, use of systematic breeding protocols have become an integral portion of reproductive management in dairy herds (Caraviello *et al.*, 2006). Ultimately, the goals are to minimize the variation in the interval from calving to first AI, increase the rate at which eligible cows become pregnant and, consequently, reduce the interval from calving to pregnancy in a consistent manner.

Based on phenotypic and genetic changes in the Holstein population (Figure 1A and 1B), it is clear that advancements in reproduction have been achieved before major increments in genotype for daughter fertility have been observed. Most of the reasons for change are related to the economic value of pregnancy and when the cow becomes pregnant, the need to manage large groups of cows without creating systems that might not be implemented due to difficulty or lack of compliance, and the need to address deficiencies in cow fertility such as poor estrous expression and detection.

In most herds in the USA, reproduction is an activity that takes place 365 days in the year, as opposed to seasonal breeding programs like in Australia. A key point in reproductive management is the rational implementation of programs that minimize human errors, which sometimes can be a challenge. Nevertheless, producers now adopt timed artificial insemination as part of the management protocol to assure that all cows receive their first AI within the first 21-d past the voluntary waiting period. Also, the typical program involves routine pregnancy diagnosis to identify non-pregnant cows and assure timely re-insemination. Most farms aim to have 100% of the cows inseminated by approximately 70 days postpartum, assure a mean interval between inseminations of 28 to 30 days and achieve median days open of 100 to 120 days postpartum.

Numerous protocols for times AI are today available, but the flagship of the industry for first postpartum AI is either the so called presynch-Ovysynch protocol, probably the most commonly implemented, and the double-Ovysynch protocol, which requires 100% timed AI for first insemination, but also results in improved P/AI. In addition to timed AI protocols, producers implement methods for detection of estrus such as tail chalking and tail painting, and electronic methods such as pedometry or use of collars with accelerometers. These strategies facilitate identification of non-pregnant cows after a breeding and timely reinsemination.

## **Expansion of Genetic Selection**

In the USA, three distinct phenotypes today are related to reproductive performance and measured as part of the genetic improvement program for dairy cattle, daughter pregnancy rate (DPR), cow conception rate (CCR), and heifer conception rate (HCR). Daughter pregnancy rate was first incorporated into the selection program and listed as part of an animal breeding value in February of 2003. Nevertheless, DPR is highly correlated with a trait incorporated in 1994 into the dairy cattle improvement program called productive life, so producers selecting sires and cows for increased productive life starting in 1994 were also selecting animals with superior breeding value for daughter fertility.

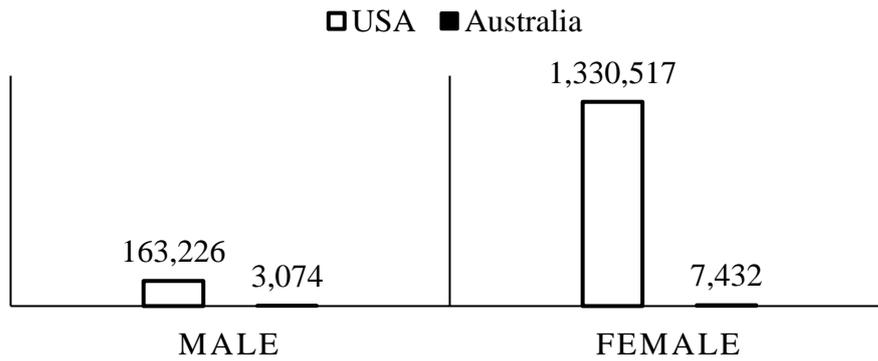
Daughter pregnancy rate is a measure of the ability of daughter of a sire or cow to become pregnant and it is measured based on how quickly a lactating cow becomes pregnant after a standardised voluntary waiting period of 60 days. It is assumed that a cow will have an opportunity to become pregnant every 21-day period, based on the typical duration of the estrous cycle of dairy cattle. Sires and cows with positive predicted transmitting ability or PTA for DPR have daughters that become pregnant faster than the average daughter in the population. For instance, if we compare two sires, sire A with PTA for DPR of +2.0 and another sire, B with PTA for DPR of 0, the latter equal to the average of the breed. For a given 21-d period of breeding, the daughter of sire A will result in 2-percentage points greater pregnancy rate than the daughters of sire B. In other words, for every 21-d breeding period past 60 days in milk, for every 100 daughter of sire A or 100 daughter of sire B, two extra pregnancies will be observed from daughter of sire A than B. Because DPR is a proxy for days open, it turns out that each point of DPR represents 4 days of interval from calving to pregnancy. Using the same two sires, daughter of sire A are expected to become pregnant 8 days sooner than daughter of sire B.

Cow and heifer conception rate are measures of probability of becoming pregnant to a given insemination when the animal is a lactating cow (CCR) or a growing heifer (HCR). All these 3 reproductive traits today selected by US dairy producers have low heritability, which is the amount of variation in a phenotypic trait in the cattle population originated from genetic variation among the individuals in the same population. In general, heritability for DPR, CCR and HCR for Holstein cattle average only 4%, only one fifth of the heritability of milk yield for Holstein cattle, which is estimated today at 20%. Therefore, progress due to genetic selection for fertility is expected to be slow, either

because of the low heritability of these traits, the lack of adoption of artificial insemination to generate all replacement heifers (20 to 25% of the newborn dairy calves in the USA are from natural service), and the fact that not all producers use the best sires for daughter fertility. Nevertheless, genetic trends for daughter fertility are in the upward direction and it is clear that producers have adopted these traits in their selection program (García-Ruiz *et al.*, 2016). In fact, daughter fertility traits represent today approximately 10% of the main composite trait used in the USA called lifetime net merit. Furthermore, traits highly correlated with DPR such as productive life and calving ability represent 18% of lifetime net merit, so producers selecting for those traits are indirectly also improving daughter fertility.

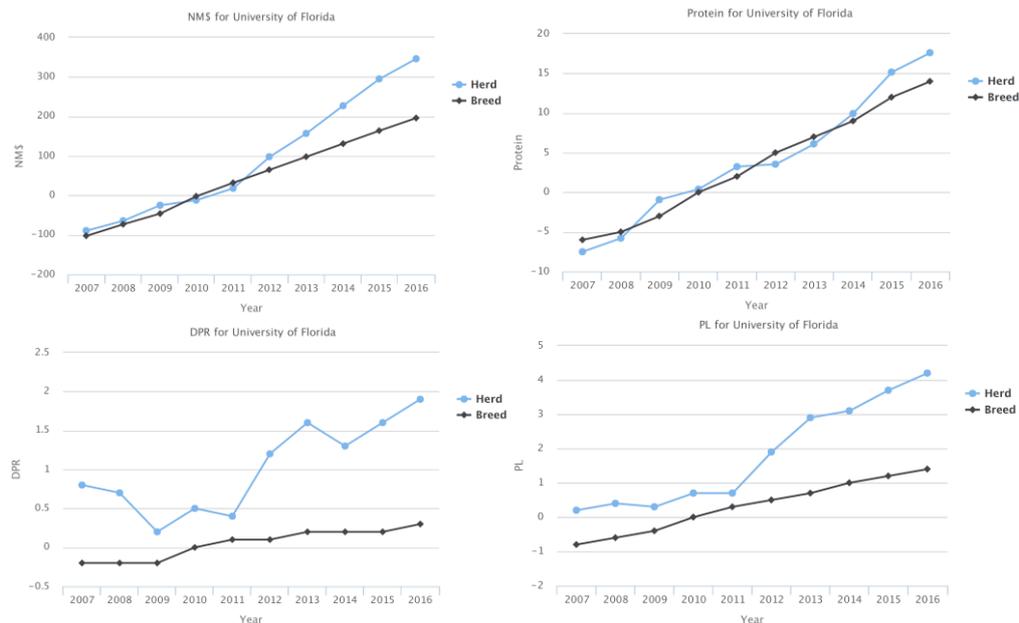
A major breakthrough in genetic selection occurred in late 2007 early 2008 with the discovery of genomic markers and development of genomic platforms for identification of superior animals. Until then, genetic selection was based on pedigree of parents and traditional progeny testing. We did not know the genes responsible for a particular trait (e.g. yields of milk or milk components), but after progeny testing we knew that bulls with daughters that were superior for a given trait, milk yield, were more likely to carry the genes that confer advantages in milk yield. Sequencing of the bovine genome that was completed in mid-2000's and published in Science magazine in April 2009 (Elsik *et al.*, 2009) revolutionized the way genetic selection is implemented. For the first time, we have now begun to understand what genes control particular phenotypes. The development of bovine-specific gene chips with variable density of markers or single nucleotide polymorphisms (SNP) allowed male and female calves to be genotyped within weeks after birth with reliabilities of 50 to 70%, depending upon the trait. Furthermore, genomic platforms for selection allowed identification of sires and cows that carry recessive lethal genes, some of which detrimental to fertility (Adams *et al.*, 2016). Perhaps the most famous of those recessive genes is a recently identified mutation in a gene that results in premature stop codon, i.e. the nonsense codon in the transcribed RNA results in truncated translation and production of a nonfunctional protein. It turns out that this mutation, better known as Holstein haplotype 1 was identified in a sire, Pawnee Farm Arlinda Chief, which is thought to be responsible for a large proportion of the current Holstein cattle DNA and results in increased risk of pregnancy loss. Therefore, genomic selection of cattle not only identified markers that control certain traits, reduced the generation interval from 6 to approximately 2 years, improve accuracy of the prediction, but also allowed producers to avoid matings that might compromise fertility by not using sires that carry recessive genes that result in less pregnancy.

Data from the Council of Dairy Cattle Breeding show that the number of dairy cattle genotyped is 1,856,049 as of June of 2017, of which the majority are females and 80.5% originated from herds in the USA (Figure 5). The increased number of males and female genotyped suggests that producers are placing more emphasis on genetic selection and genomics has become a large component of the selection program implemented by the US dairy industry. In fact, the larger number of females than males indicate that producers are not selecting not only on the male side, but also in the female side with use of sexed semen from superior sires in superior females, and embryo transfer from in vivo and in vitro produced embryos from superior females.



**Figure 5. Number of males and females genotyped listed in the Council of Dairy Cattle Breeding (CDCB) website in June of 2017 ([https://www.uscdcb.com/Genotype/cur\\_ctry.html](https://www.uscdcb.com/Genotype/cur_ctry.html)). The total number of dairy cattle genotyped worldwide was 1,856,049 of which 80.5% were from the USA. Australia has listed only 10,506 dairy cattle genotyped listed in the CDCB website.**

At the University of Florida dairy unit, since 2009 we have placed major emphasis in selecting sires with positive daughter fertility, high productive life, low somatic cell score, while keeping a high rate of gain in yields of milk solids. Our program is the typical implemented by dairy producers, with focus primarily on the male side and retention of almost all females. We genotype all our newborn heifers for research purposes, but that has allowed us to follow the genetic progress of the herd over the years (Figure 6). It is clear that the genetic progress based on genomic values of cows at the University of Florida herd have increased at a faster pace than the average of the Holstein breed that has been genotyped. These results suggest that selecting superior sires for daughter fertility, concurrent with selection for yields of fat and protein has allowed the University of Florida herd to achieve greater genetic progress in fertility than the average of the herds that submitted samples for DNA screening, but without compromising production.



**Figure 6. Genetic progress according to year of birth for lifetime net merit (NM, US\$), protein yield (lbs), daughter pregnancy rate (DPR, % points), and productive life (PL, months) for Holstein cows at the University of Florida (Herd) and the Holstein population subjected to genotyping. It is clear that since 2010, the genetic progress for NM, DPR and PL has been greater at the University of Florida than for the Holstein breed, at the same time that progress for yield of milk components has maintained the same pace as that for the Holstein population.**

## Summary

Reproduction continues to be essential for the economy of a dairy farm and producers in the USA have placed major attention to management factors that influence reproductive performance in their herds. In the last 16 years, reproductive performance in dairy herds has substantially improved, in part because of better transition cow management, increased attention to peripartum health issues, improved facilities and nutrition, implementation of more rational reproductive programs that take advantage of breeding on estrus concurrent with implementation of timed AI protocols to assure breeding with high fertility. More recently, the era of genomics has made producers to emphasize fitness and fertility traits concurrent with production traits, which allowed continued genetic gains for yields of milk and milk components at the same time that daughter fertility improved. Today, it is not uncommon to find herds with 500 to 5,000 cows with production above 40 kg of milk/cow/day year-round (~ 13,000 kg/cow/lactation) and with measures of reproduction such as pregnancy per AI and days open of 45 to 50% and 100 to 110 days, respectively.

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# PAST, PRESENT AND FUTURE RESEARCH IN DAIRY PRODUCTION AT THE UNIVERSITY OF SYDNEY

**Sergio (Yani) Garcia and Cameron Clark**

*University of Sydney*

## **Introduction**

Established in 1959, the Dairy Research Foundation (DRF) is one of the oldest foundations of the University of Sydney. The DRF constitutes the 'arm' that connects University teaching and research with industry (farmers, processors, service providers, commercial companies) and the community, attracting funding and resources for staff and students and enhancing science-based solutions for our industry.

The Sydney Dairy Science (SDS) group comprises the staff and students who, using University and industry resources and the DRF as the connecting arm with industry, carry out the teaching and research work in the dairy area.

After over 56 years of history, the DRF has made very significant contributions to dairy science, encapsulated in over 1,000 peer review papers and well over 100 PhD's. The DRF has been home of famous physiologists, nutritionists and system experts and over the last 10 years has seen the current SDS group expanding into the areas of automation and technology as key drivers of production efficiency. In this paper, we summarise key recent and present achievements by the current SDS group and discusses the opportunities for advancing dairy production in Australia through new approaches and science-based solutions.

## **Recent research: FutureDairy**

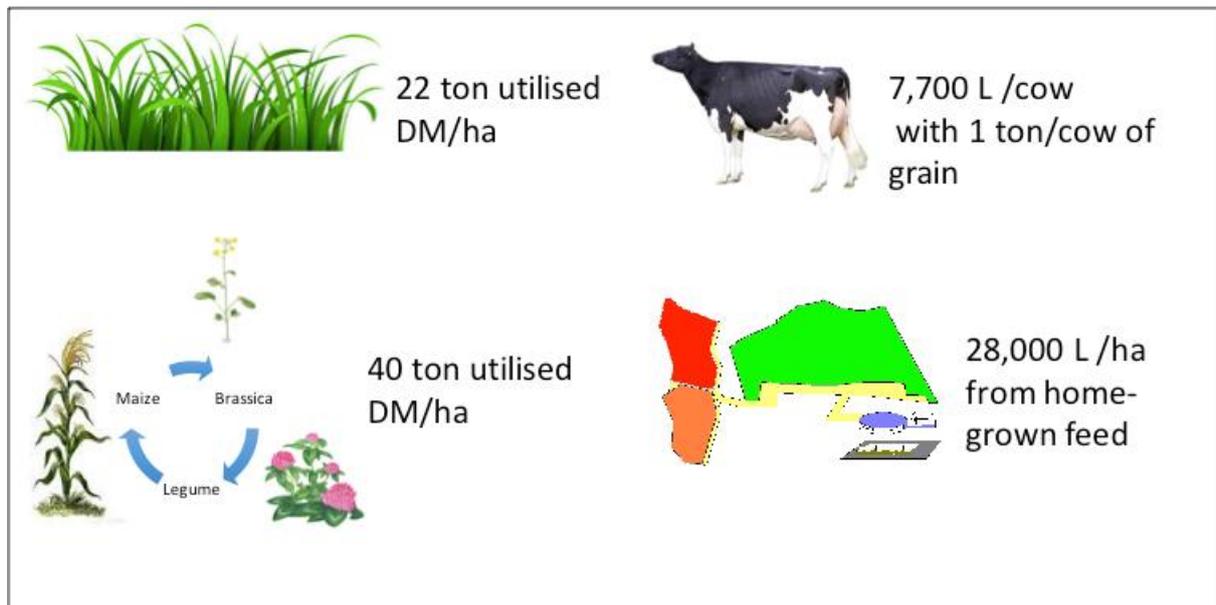
FutureDairy is an industry-driven program that commenced in 2004 to address key industry challenges that farmers were expected to face in the future, namely land, water and labour constraints ((Garcia and Fulkerson 2005).

FutureDairy tackled those challenges through two main programs: Feedbase (land and water use efficiency) and Automatic Milking Systems (AMS; labour efficiency) (Garcia *et al.* 2007). Both programs translated into real R&D journeys that have resulted in significant achievements and benefits for the Australian dairy industry.

In Feedbase, key achievements are summarised by the well-developed concepts of Complementary Forage Rotations and Systems (CFR and CFS, respectively), which achieved 22 t DM/ha of utilised pasture; over 40 t DM/ha of complementary forage crops; and almost 30,000 L milk/ha from home-grown feed (Garcia *et al.* 2008; Farina *et al.* 2011) (Figure 1). The CFS system had 100 cows in 21 ha over 3 years, producing 7,700 L/cow from an 80% forage diet grown on farm.

The last phase of the program saw the principles applied by commercial farms in the Hunter Valley (both through modelling and real changes on farm) and Northern Victoria (modelling), all of them increasing milk from home grown feed during the 2-year project.

Limited extension resources, together with the inevitable higher complexity associated with intensified systems, have constrained broader adoption. However, this work is still very relevant for the Australian dairy farmers, as it shows not just the potential of intensified pasture-based systems, but also the know-how to achieve them.



**Figure 1. Key achievements by FutureDairy (Feedbase)**

In AMS, the journey included three main phases.

1. Pasture-based AMS. The first phase demonstrated that AMS on pasture (grazing) based systems was not only possible but also competitive with conventional systems, as our research AMS farm achieved consistent pasture utilisation levels  $>15$  t DM/ha (Clark *et al* 2016).
2. Co-development of the Automatic Milking Rotary (AMR) with Sweden-based manufacturer DeLaval. This phase saw the first prototype of the AMR (a 16-bail AMR) commissioned and trialed successfully at EMAI, NSW DPI. The AMR is now a commercially available technology, and one AMR is currently installed at the University of Sydney's dairy farm (Corstorphine)
3. Large Herds AMS: after co-developing the AMR, focus was placed on developing better strategies and management practices to enable adoption of AMS by larger herds in Australia. This phase was successfully completed in June this year, despite very adverse circumstances (partner farm exited industry; milk price effect).

All the above achievements and learnings, led by Associate Professor Kendra Kerrisk, have been captured and encapsulated in accessible ways such as the AMS Management Guidelines for Large Herds (freely downloadable at [www.futuredairy.com](http://www.futuredairy.com), Figure 2), web-based information, technotes and technical articles, scientific papers as well as many thousands of media hits.

A full list of publications (scientific and technical) arising from FutureDairy can be found at [www.futuredairy.com/publications](http://www.futuredairy.com/publications). See also the recent chapter by Rudenberg, Lyons and Kerrisk (2017) on Large Herd AMS management.

**1** Robotic milking for large herds:  
**Box Robots or Robotic Rotary?**

This presentation explains the basic differences between box robots and robotic rotaries.

Use the arrows below to navigate      Click Full Screen for best viewing

There are four Prezis in this theme.

|                        |                      |                       |
|------------------------|----------------------|-----------------------|
| <b>1. Introduction</b> | 2. Basic Differences | 3. Voluntary Movement |
| 4. Batch Movement      |                      |                       |

**1** Box or Rotary? Introduction  
Prezi 1 illustrates the basic differences between box robots and robotic rotaries. **Click on the graphic to view the Prezi.**

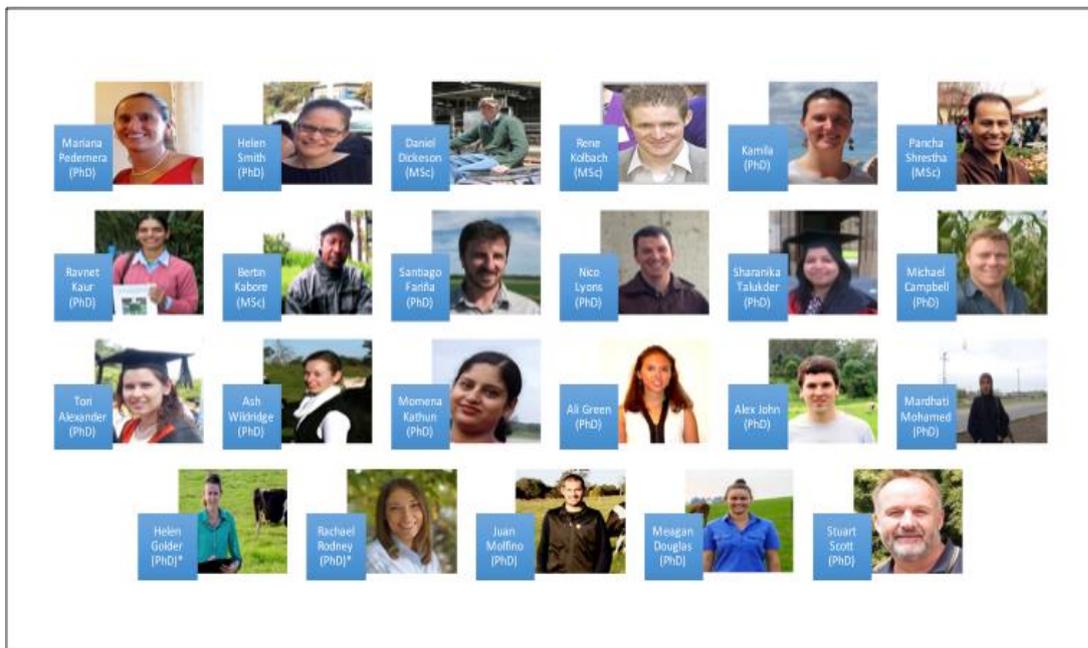
**Main Document**  
AMS Options for Large Herds

**Related Info**  
Dairy Australia AMS overview  
AMS Farmer Article  
pp 13-15 AMS Guidelines 2010

**Further reading**  
**The Info Sheet library**  
contains detailed information on a range of topics.  
**AMS Case Studies:** In 2013 FutureDairy conducted labour and lifestyle audits on five commercial AMS farms in Australia.

**Figure 2 FutureDairy's AMS Management Guidelines for Large Herds (available online at: [www.futuredairy.com](http://www.futuredairy.com))**

In completing its goals, FutureDairy has made a very significant contribution to advance research training through post-graduate programs at the SDS group (Figure 3).



**Figure 3 Post-graduates at the Sydney Dairy Science group over the last decade and current (\*Drs Helen Golder and Rachael Rodney supervised by Dr Ian Lean, Scibus)**

The next step in the AMS journey is to fully address key barriers to adoption, which are encapsulated in the perception by many farmers that AMS is not an economic/viable option; and that efficiency can be lost in AMS systems. A combined RD&E program has been designed to address this through improving economic narrative, enhancing extension and delivering of recent and past research; and directly addressing one of the biggest negative perceptions of AMS through research: complexity of management. These 3 pillars form the basis of the 'FutureDairy 5' initiative plan presented to Dairy Australia.

## Present research

In addition to all the work on voluntary traffic in AMS (see [www.futuredairy](http://www.futuredairy) for more details), current and future research by the SDS group is driven by the "HEADS" concept (High Efficiency Automated Dairy Systems"), which, conceptually, aims to achieve high performance dairy systems in which food (milk) is produced in the highest possible efficient way for the benefit of the animals, the land, the environment, and the farmers.

HEADS represents the concept of "smart automation" (see below) and provides the framework within which our research fits into place.

Smart automation is much more than 'the taking over of a repetitive task' from humans. Smart automation is:

- Strategically directed (e.g. labour saving, efficiency gain, management)
- Tailored to individual farm's (and farmer's) needs, as what works for one farmer may not work for another one.
- Self-learning: not just repeating the same but improving and adjusting dynamically and intelligently (eg mastitis detection: actions change depending on what type of pathogens)
- Linked to a direct automated action
- Controlled by the farmer or manager who decides on acceptable boundaries for the actions but who is not involved in the action him/herself.

The implicit concept here is that real automation and robotics on farm go well beyond sensors, data capture and data analysis. These are the easy bits. The real challenge for R&D is in data optimization (by definition true optimisation should cover the tailoring and self-learning aspects referred to above!) and the translation of the 'optimum' into an (automated) action.

## Future opportunities

A few years ago we developed a conceptual model that represents losses in pasture utilisation arising from inadequate input (water, fertilisers) and grazing management (Garcia *et al.* 2014). The same model can be applied to any aspect of dairy production, e.g. forage crops or feed production, and cows' performance. The model suggests that there are cumulative levels of losses (inefficiencies) that prevent the achievement of top yields for pasture, forage and animal production (Figure 4).

Cumulative losses on each and all of the key components of a dairy system (cows, feed, and people) have an additive and negative impact on profitability, explaining why similar farms (land, resources) can differ so greatly in their bottom line.

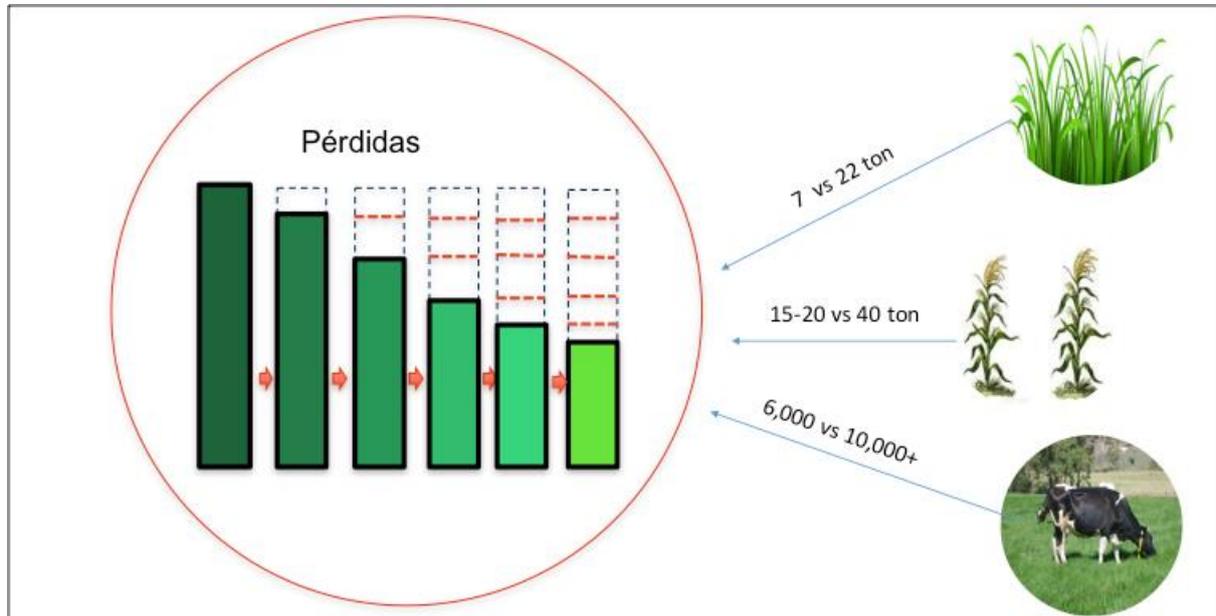
## New approaches to reduce losses

Losses can be reduced by improved management practices. These in turn means adequate and timing actions on the ground on any and all aspects of dairy farming, all the time.

Education and training go a long way towards practice change on farm and, by comparison, our industry is at the top of the chart in terms of training and capacitation programs available for farmers.

However, relying on just education and training is not enough and the proof is that several key indicators of efficiency (e.g. pasture utilisation, production per cow and per ha, among others) have

increased only slowly despite significant industry investment in education and training programs in those areas. The expectation that all farmers need to be top-performers at farm planning, managing pasture, feeding cows, managing people and all the other key activities in dairying is unrealistic. Education and training should of course continue, but new, complementary approaches are needed as well.



**Figure 4 A conceptual model representing the losses (wastage) in key aspects of dairy farming (adapted from Garcia et al 2013)**

One of these approaches is to reduce complexity in day-to-day management via ‘smart automation’. This is basically adding sophisticated complexity but behind the scenes. On the surface it means that farmers, in the future, will not need to spend time thinking on (e.g.) how to best allocate pasture and supplements to cows, but rather be confident that a trustable, smart automated system is doing it for them.

For instance, for some farmers it will suffice to be in control of the ‘boundaries’ of the decision making process, whilst leaving the actual decision to a ‘smart automated system’ (see Hills et al. 2015 for more details). For example, in feeding concentrates, they may decide on the range that cows can get on a daily basis (e.g. from 3 to 9 kg concentrate/day), knowing that a computerised system will be using all possible information –including history of individual response by each cow- to optimise the amount that each individual cow should be fed to maximise marginal response. We are currently developing such system working collaboratively with data scientists from the Center for Translational Data Science at Sydney University. Preliminary results suggest a net gain of 10% (i.e. 10% more milk with same amount of concentrate) is possible.

Another example of ‘smart automation’ is in mastitis detection. Several systems already exist that can monitor milk in line (e.g. electric conductivity [EC] in all AMS and some conventional systems), but they are limited by accuracy, time of detection and lack of connection to an automated action.

To address this, we first looked into over 250 indexes developed ad-hoc from EC and milk yield data and different methods of data analysis such as statistic process control. The additional gain in accuracy and time of detection was small (Khatun et al 2017a).

We then changed the approach, using multivariate statistical models capable of using all available information for each cow (e.g. milk yield, milk yield per hour, EC, incomplete milkings, among others.)

and select which variables were significant. This proved to be very efficient, achieving high levels of accuracy in detection. We then tested this model with data from a farm in Tasmania and the model was able to detect practically 100% of the actual cases of mastitis the farm had (this work was presented by PhD candidate Momena Khatun at the 2017 American Dairy Science Conference, PE, USA).

## Conclusion

From the development of intensified forage-based systems to consolidation of pasture-based AMS and the co-development of new robotic options like the AMR, our SDS group has been at the forefront of advanced, science-based solutions to the big industry challenges. By all metrics the contribution of this group has been very significant, in particular in terms of training the researchers and leaders of tomorrow.

Our group is 'heading' more and more towards 'HEAD', the framework for 'smart automation', which in turn opens up huge opportunities to simplify complexity by, paradoxically, adding 'controlled' complexity in the background (behind the scene), freeing precious time for the farmers and given them piece of mind that management practices are being truly optimised.

The number of challenges ahead is immense and so are the opportunities for RD&E. But this is the future of dairying, so we can either do it ourselves, tailored to our farmers' needs or continue to see our industry drafting below its true potential.

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# THE 'FARMERS OWN' JOURNEY

## Tim Bale

*Farmer, Manning Valley NSW*

Currently we milk 280 cows (predominantly Holsteins) year round and average 8,900 litres per cow. Annual production is 2.4 million litres at 3.9% B.F and 3.2% Protein.

Our home farm at Stewarts River is 413 acres (167 hectares) with some bush and 102 hectares milking area.

To understand where we are we need to go back nearly 17 years to deregulation which is what started us on this path.

I have never been one to accept the status quo and Taree was one of the first dairy areas to form a collective bargaining group.

Over many years we politely argued for a better price, sometimes winning and sometimes being very disappointed.

A few years ago during one of these bargaining meetings, full of disappointment I felt enough was enough. The processor has a contract with Woolworths and dropped the price, what more proof do the ACCC need.

The challenge to me was 'You talk to Woolies and find out how hard it is for us'.

So I wrote to every director of Woolworths at their home address.

The general manager rang me and after two years of meetings the rest is history.

When we started negotiations it was all about 60-70 million litres of milk and 60 odd of our members.

We had to make a tough choice when volumes were set at only 17 million litres and who would come.

A lot of farmers did not want to change, so seven farmers became the Manning Valley Fresh Group and the challenge was to get everyone on the same page.

Needless to say it wasn't that easy and we had to get around what they (Woolworths) saw as consumer concern. What do we do with bobby calves, how would the public view our farm.

Were we a safe bet for Woolworths or could this contract cause some problems.

So that's what this talk is about 'What could we offer as farmers to warrant being paid a better price?'

We ran a taste test with 4 Woolworth's executives using Jersey milk, milk straight from the vat, branded milk and then their select milk. They raved over the Jersey milk and wouldn't drink their own select brand.

It was the low fat test and standardisation which took the taste away. So we needed to guarantee our milk quality, not only on the Total Plate Count but components and Somatic Cell Count as well.

We set figures that at times are hard to meet but we had to change our thinking.

Butterfat was always an issue for us in early spring when milk exploded but fat test often dropped to 3.4% or less.

I always believed that feeding hay to lift fat test was not economic especially when volumes were high.

But now we feed wheaten hay and at times straw to keep fat test above 3.75%. Even 1 bale per day can work well.

Protein was another issue as in January, February our test would drop to 2.9%.

We mix our own grain and we are keeping things cheap, no protein meal and minimum additives.

On advice from Bruce Hamilton we set up to handle Canola Meal and lifted the inclusion rate to 30%. We also went to a full nutrition mix and kept it going year round.

Even when feed is good we have kept up a higher grain rate of 6-7kg average per cow and kept Canola at 20% at least.

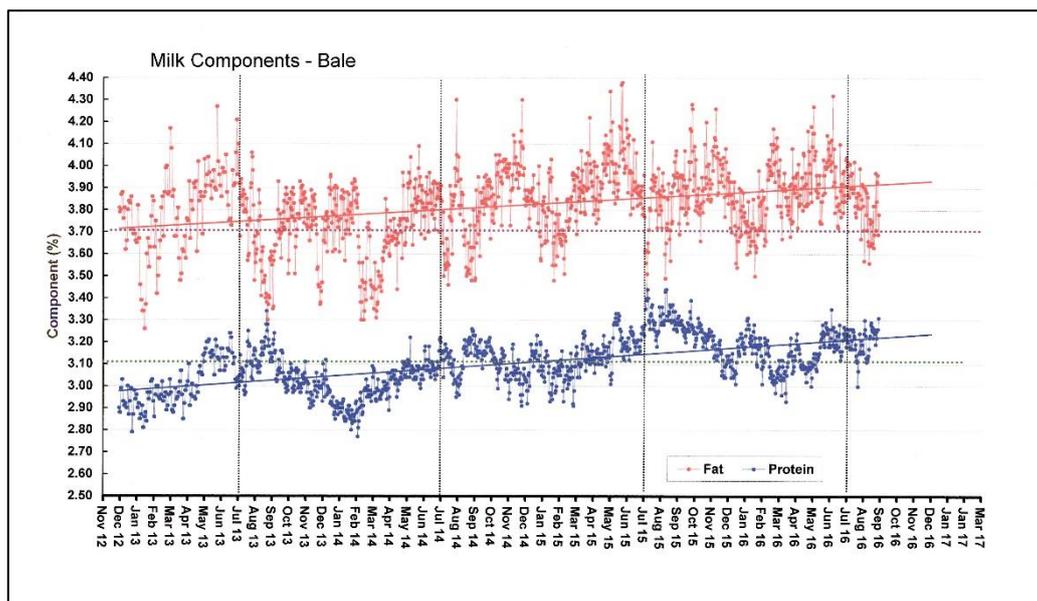
The results were good and now even in January/February protein stays above 3.1%.

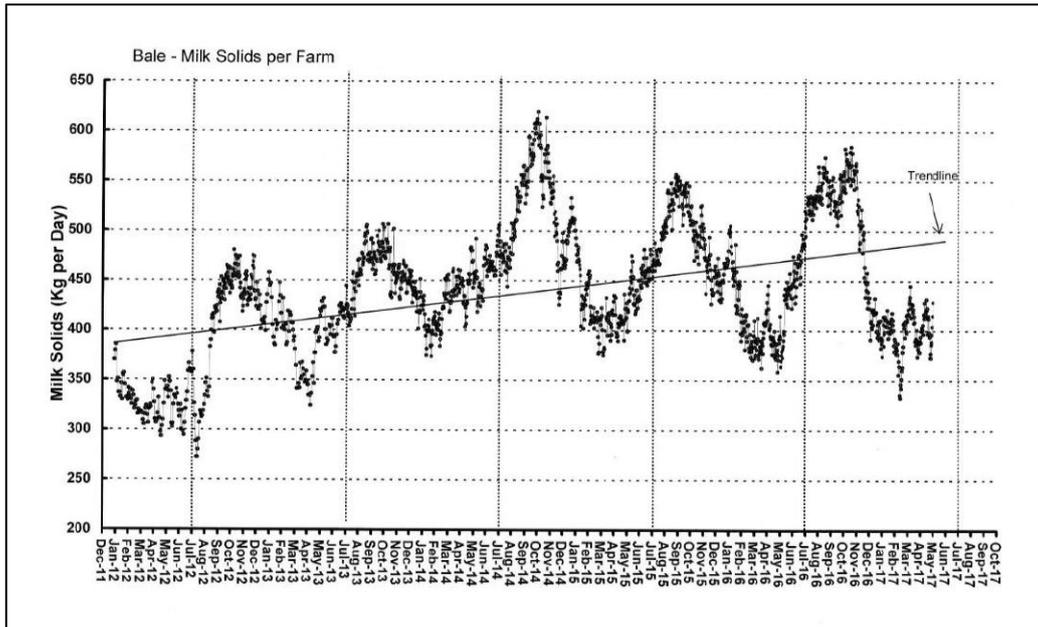
Somatic Cell Count was another challenge. It's one thing to have the average below 200,000 but every day below is almost impossible.

We purchased a cell counter machine and now as a matter of policy, we test every fresh cow before she goes in the vat and we also test treated cows that visually look okay.

We have always herd recorded but sometimes monthly individual results are not frequent enough to pick up on the problems.

The biggest spinoff to all of this diligence is the overall milk production. We have lifted annual production by nearly 20% and total solids have gone up nearly 25%.





This has all come from outside advice as well. Bruce Hamilton for nutrition and Matt Thompson for pasture management and fertilisation.

Advisors give you the confidence to make the changes and continually challenge you to stay on track.

Growing good pasture and feeding the cows well is not enough and we had to face the consumer perceptions as well.

Calves were the big one. Like everyone calves were in an old dairy with makeshift pens and feeders, mud everywhere etc.

It became a no brainer that bull calves had to be looked after as well. No more knocking on the head.

We built a new calf facility with pens designed for five calves, good ventilation and good shelter.

Calves need to be kept dry and draft free. We established procedures for calf rearing that everyone had to follow, including a diary so a different feeder is always up to speed.

All procedures on calves are recorded, bulls are kept for several weeks and only euthanised if sick.

We have also done the Dairy Australia Euthanasia Course.

We are currently preparing an animal welfare manual to follow with efforts made towards hoof care, sick animals and lame cows.

The other big issue is general appearance of the dairy. Our group assessed each other's dairy surrounds and made comments on needed improvements.

Is it clean, is there rubbish around, are you proud to show people your dairy?

Marketing was also a new challenge for us. Interviews with radio, TV, endorsements, our picture on the label and even tastings in the stores.

We are also looking at a website and running a Facebook page which is really outside the square.

In all of this there are some negatives like are we setting a standard that is too hard or will be forced on everyone else.

The bottom line is that if you want a better price you have to be prepared to put something on the table.

We can't just whinge the industry better, we have to take responsibility and make it happen. Never give up.

And are we finished, no, we are always looking for plan B, this Woolies deal may not last and we need to be ready for the change.

Either look for alternatives or be so damn good that Woolworths can't afford to let us go. I'm sure there are still other opportunities out there, there are more supermarkets, other factories and new deals every day.

**Our milk is no different to yours when it leaves the farm, but by hell  
it is different when it makes the breakfast table.  
That's what we need to fix....**

# GUNDOWRING FINEST ICE CREAM

## James Crooke

*Gundowring Fine Foods*

### Introduction

Gundowring Finest Ice Cream is churned on Sarah and Stephen Crookes family farm in North East Victoria, using fresh milk from the 500 cow herd. Started after a search for diversification led to thinking about value adding to Crookes milk, and from that it has grown to become a product and brand recognised around Australia for quality and strength of values.

Sarah and Stephen's dairy farm was running as a successful enterprise, and having been involved in the research and development side of the dairy industry for some time, the Crookes were looking for a new challenge.

### What to do?

Setting out to find the right product was the first hurdle. After considering the current and potential future state of the dairy industry and the region, the Crookes investigated a number of industries that would let them diversify on the farm.

As they worked through the process, they kept arriving back at the research work they had done on farm, and the exceptional quality of milk it had resulted in.

They began to explore the possibility of value adding to their milk before settling on Stephen's idea; Ice Cream.

From this decision began a journey into the world of frozen dairy products, and like Alice down the rabbit-hole, the Crookes discovered that ice Cream and life beyond the farm gate was going to be anything but easy.

### Lessons learned

Sarah and Stephen quickly learned that while they had a pretty firm handle on what it took to produce quality milk and they were building an understanding of what it took to take it from cow to cone, they had no idea how to actually get their ice cream into the hands of consumers.

They were quickly schooled in the basics of marketing, brand building and the need for a dedicated and reliable cold chain to get the ice cream from Gundowring to the shops in Wodonga, then Melbourne, then Sydney and beyond.

It became evident that a brand was much more than just a pretty label on a tub. They embody everything about who you are, what you are producing and why you are taking the trouble to produce it.

Gundowring Fine Foods has always been about the people, the product and the place, so for the tiny business just finding its feet, taking the time to get this right was incredibly important.

Distribution has been a constant challenge from day one. Early on a friend in the industry told Sarah and Stephen that they would have to work hard at getting their ice cream to the customer and ultimately the consumer. The distribution industry is not set up to be friendly to the little guys. Route to market is in many cases controlled by the multi nationals and the cold chain would need to be rock solid for as fragile a product as ice cream to get to the stores in a solid state.

## **Success!**

The learning curve was very steep in the first few years, but it was paying off. The ice cream was popular and the Crookes were taking calls from further and further afield.

Soon ice cream was being sent out to other states and there was even interest from overseas.

The Crookes sons, James and Alex were called home whenever possible to help with the ever increasing demand, and James began working in Melbourne as delivery driver and salesperson.

Success started to take a toll though, and soon the Crookes realised they couldn't run the dairy farm the way they wanted whilst continuing to grow Gundowring Fine Foods.

A solution was found next door with the Holloway family looking to step into Dairy farming, and an agreement was struck.

With the pressure off, Sarah and Stephen again turned their attention to the future. Ever the pragmatic duo, they began to discuss their futures, the future of the farm and ownership of the business they had recently built.

James and his partner Iris were working hard in Melbourne attending farmers markets and building the brand presence in the food scene there.

Another agreement was struck and James and Iris uprooted from Melbourne and settled on the farm at Gundowring. Discussions began into the future of the business and the farm, and after a lengthy process involving the Crookes younger son Alex, James and Iris took control of Gundowring Fine Foods in 2013, almost ten years to the day after Sarah and Stephen sold their first tub.

## **Where to from here?**

James and Iris continue to build Gundowring Fine Foods, focusing on strengthening the distribution network and production process on farm. They prefer to grow the business slowly but surely, giving themselves the chance to grow with it.

Recent changes within the dairy industry have the family back at the kitchen table, discussing the future of dairying in the region and the direction of their business.

## **Conclusion**

Ultimately the family has had to fundamentally shift its view beyond the farm gate, and learn many lessons in doing so. Understanding the value of the brand and the brand values have been incredibly important in making a product the Crookes can be proud of.

The core beliefs have helped inform many decisions over the years and continue to guide the thought processes as the Crookes look to the future.

# CHANGE AND THE ADOPTION OF NEW TECHNOLOGY

## Rob Cooper

*Farmer, Manilla NSW*

### Introduction

Change is an inevitable part of life. We have to work out how to live with change and survive as a business, more specifically as a milk producing business. Adopting new technology and research outcomes is part of both short and long term strategies that we need to adopt to survive as dairy farmers.

### Background

I farm 2400 ha at Manilla, 60 km North West of Tamworth. The business started in 2004 milking 350 cows producing 1.8 million litres. Since then it has expanded, purchasing 3 neighboring properties and growing to currently milking 1500 cows producing 12.6m litres that is, 935,000 kg milk solids per year. The farm is operated under shared equity arrangement with 3 other partners.

The cows are calved in two batches half in autumn and half in spring. The cows are all pasture fed, with a grain mix supplement in the dairy whilst they are being milked. There is 330ha under centre pivot irrigation growing a combination of fescue, prairie, ryegrass and clover, plus 25% of the irrigation area is under kikuyu. We use liquid fertilizer through the pivot irrigation system after each grazing. The combination of pastures varieties and boosting growth from nitrogen, aims to grow the herd's daily requirement in fresh pasture, grazed with minimal silage supplementation. Oats and sub-tropical grasses are grown in dryland arable areas to supplement grazing.

The cows are milked through to two rotary dairies, one 50 unit and the other a 60 unit. Both rotaries are set up to be operated by one person.

### Change

Change is an inevitable part of life, things are always changing, as much as we would like to get comfortable in a certain situation and lifestyle with no changes. I think something that many of us desire is that things would not change, 'I am comfort were I am at, if only things would not change'. But change is part of life.

In business generally and more specifically on the dairy farm, the terms of trade continue to get reduced. The price never keeps rising to keep up with the rate of inflation but on the cost side, they do keep up with or exceed the rate of inflation, especially when we average out over a long period of time and historically.

I remember back at Agriculture College in 1980, the lecture was definitely talking about change, the diminishing terms of trade. But he said we had an advantage in agriculture. This advantage was the world population was increasing and at an ever increasing rate. That in the future there would be a greater demand for agricultural products with limited area to produce them from this price rises would follow. Well population has increased but the world's population isn't increasing as quickly as most people predicted. But there is one thing that has been highlighted over that time period and probably if analysed over the last 2 centuries, that is that new technologies and improved ways of doing things through research and on farm development, has outpaced the demand for agricultural products from population increases.

We can look at all agricultural products around the world and there is nearly a surplus in all of them. In the dairy industry just three years ago the headlines were saying the dairy industry would never produce enough product to meet the demand in China and Asia. Twelve months later there was an oversupply of milk and price dropped to ten year low.

Our productivity gains through adoption of new technology with potential increasing in areas of agricultural land in such areas as South America, there is never going to be a shortage of food that will drive up price.

So my main point is that we cannot sit back on our present dairy farm and not change. Some people were advocating just sit back and wait for price to increase based on there would be increased demand around the world. It is not going to happen. There may be short term supply and demand fluctuations in price and demand, but long term we are in an ever changing system. Each one of us have to address change in some form.

It doesn't matter whether you are a small farm or large farm, modern or maybe haven't updated to the latest technology. I want to point out that each of us have to look at the future and how we are going to change and adapt our businesses.

My grandfather was a dairy farmer in Tasmania and he cleared the original land of trees to grow potatoes and milk a herd of 40 Jersey cows. One thing I can remember him telling me was to be always doing something positive and make the farm better, whether it even just something simple like a new fence.

Change doesn't have to big things but can be little small changes.

I would like to break it down into two areas.

1. Those changes that make a difference in the short term, for example, a feed change
2. Those changes for the long term, for example building a new dairy or buying a property. Our next two speakers are good examples of farmers that recognized the need for change and have made major changes in their dairy businesses and will continue to.

So I want to share with you some of the changes made and the adoption of new technology at Split Rock Dairy. When looking at new technologies and changes to our system I firstly have to go to various information sources, whether that is the neighboring farmer, going to field days and on trips to visit other dairy farms. I spend time reading newspapers and magazines. I use consultants that have done a lot of the background research, maybe which is for a one off particular subject or over regular visits. I do read and research a lot and look at the way others do farm, that is a priority for me. The main areas I am looking for is university research done on a product, how other farmers might have used it and then look at how that can be implemented or brought in to my present system. I try to do a partial budget on the change or new technology. Depending on the size of the change it can be very simple, extra income minus cost, or for a major change involving a major investment I would carry complete farm budgets.

### **Some of the changes done at Split Rock Dairy?**

- 1) Feeding -when upgrading and modernizing the dairy I made changes in 4 areas;
  - To have a system that was versatile and could use a combination of grains, wheat, barley and corn. This is to help in the balance of energy supplied to the cow and in milk solids production. There is a combination of 5 silos to store different quantities and qualities of grains.
  - A disc mill and batch mixing plant was installed which allows for better processing and mixing of the rations over a roller mill.

- Protected dairy fats are used to better supply the energy requirements to the high producing cows. Then the feeding system allows this to be feed just to the high production cows that need it and can give the best return back from this fairly expensive supplement.
  - Feeding the transition cows with anionic salts products and protected B vitamins that have really helped our cows calve and reach peak yields.
- 2) Breeding and genetics- when looking at the research on genomics I saw it was the way forward for the future, and also the advancements in sexed semen technology. The program I have implemented involves;
- All heifer calves are genomically tested at one week old.
  - The genomic information is used to cull any genetically inferior calves and then also used in the mating program to match AI bulls.
  - The heifers and top cows are mated to 100% sexed semen
  - Other cows are mated to wagyu and beef for better return on those calves.
- 3) Rotary Dairies,
- Both rotary dairies are set up with auto ID, individual feeding, auto cup removers and teat spraying, auto drafting and auto backing up gate to keep the cows moving smoothly.
  - All the cows have a rumination and activity collar. I find the rumination really helps in heat detection and identifying cows with; mastitis, post calving problems and sickness.
- 4) Irrigation
- All irrigation is by centre pivot irrigators, for accuracy, energy and labour efficiency.
  - Liquid fertiliser is applied in small regular amounts after each grazing to match the amount of pasture removed.
- 5) Pasture species
- Prairie and fescue grass with white clover is best suited to our climate with good irrigation, fertiliser and grazing management. The latest breeding of new fescue varieties is producing grass with soft leaves well suited to grazing or making silage.
  - Gibberellic acid is use to boost winter production of pastures.
- 6) Consultants
- I use a number of consultants both paid and those that support products.
  - Recently I changed agronomist to one that mainly does cotton, he offers a different perspective and challenge that is really helping the business.

## Conclusion

So this has been some of the changes made and I will continue to make changes in our farm business. I encourage each one here, whether you involved in dairy farming directly or in the support industries, do spend some time to plan for the inevitable change and adoption of new technologies. Ones that suit your system and where you want to be in the short and long term. It is not always easy but essential.

# HOW TO MAKE THE MOST OUT OF PROFESSIONAL CONSULTANTS

## Chris Shirley BVSc

*Dorrigo Veterinary Clinic*

To start, I feel it is worth asking what professionals working in the Dairy space are essentially wanting to achieve. Whilst I can't speak for everyone, talking to veterinary colleagues I know, it is apparent that fundamentally, we all want to make a difference!

We do this by helping our clients run their farms as well as possible. I am confident this sentiment is widespread. Though the mainstay of my practice is in pregnancy testing cows, what I really want to accomplish is a well performing herd for my clients, helping to create farms that are constantly moving ahead over a broad range of areas.

There are not many farmers out there who would have a true appreciation of how well equipped their Vet is advise beyond the normal subject of animal health.

Like most professions, Veterinarians have a mandatory process of continuing education which equates to about 1 week per year. Workshops and conferences no longer focus on updating us on the latest way to pregnancy testing a cow or do caesarean sections. The variety of topics we now cover very much leans towards herd disease investigation, improving management procedures and implementing change. There really isn't much focus on the individual cow or calf.

When a client comes into the surgery, asking about herd health or farm management issues, we get truly excited! This is the sort of stuff we train for and love being involved with. You will find that most professional people working in the farm space are genuinely involved because they want to help. Remember and take advantage of that.

Most professional services are expensive. It is important to get maximum benefit from your vets, agronomists, nutritionists, accountants or any other service. So, how do you do that?

1. Be a good client, and build solid relationships

There are basic necessities that help to create a good business relationship. Pay accounts on time and have reasonable facilities, be organised and importantly, support the services that your providers offer. The benefits will be twofold.

As a regular client of a professional service such as a Vet, their capacity to support you is maximised. A working knowledge of the property, its data and management etc. will be a tremendous asset when formulating a resolution.

The reality is that, if there isn't an adequate call for specialised dairy services, like any other, they will cease to be available. The investment of resources by providers is, as you would expect, tantamount to the demand.

2. Be persistent, patient and clear about what you want

Every professional will have the clients who wander in for a chat about an issue, but are not clearly able to articulate the desired outcome. From our side of the counter, how can you help someone, if you can't get a true understanding of their needs?

My suggestion is that if you have an issue that needs to be addressed, think it through so that you are clear what the issues are, and then make an appointment to see someone to discuss them. Being slightly formal in your approach conveys to everyone that you are serious in your concerns.

Be prepared for some of the bigger issues to take time to turn around. Recently I worked with a farm that had a considerable cell count problem. It took 3 months to get the problems defined, and it will take another six to bring it under control. Farm problems are often very complex and usually complicated by staff issues, the weather and seasons.

3. Ask your Vet/Agronomist what vision they have for your farm

As a professional service visiting numerous properties, you tend to see missed opportunities everywhere, and more importantly you see the potential of the farms you work on. Sure we are not farmers, and some of our ideas may seem unrealistic, but generally they will have a sound scientific basis, often with a lot of data to support them. Seeking someone's contribution sends a strong message that you have confidence in their skills, and the reality is, we all seek that sort of validation.

4. Avoid cherry picking advice

We all get advice from a range of sources, and that's sensible. What we often see though are farmers getting advice from their vet, the local produce store, their nutritionist and the local agronomist, and then choosing what advice they want to follow. This is not the best practice. For important business decisions, it's much better to try and get everyone in the room together, and 'kick the can around' as a collective. More often than not, you will find that everyone is singing the same song, and that you can pick up different specifics from the various sources.

5. Use your data

Most farms I visit have access to electronic data going back a number of years, but seldom is this data analysed to help make improvements for the future. With technology becoming more commonplace, farmers have the ability to store generous amounts data, but it is of limited use when it isn't utilised.

Clients often seem reluctant to send herd records so I can see how things are going. To get maximum benefit from your professionals, ask them to look over relevant data. This makes our job easier and will ultimately be more rewarding for us all. One of the most important things we learn at University, is the emphasis on reading the available literature and how we look at data and statistics.

6. If there is a problem, work through it until it is under control

We all make mistakes, and sadly these are what we tend to learn the most from.

Looking at the way Adam and Donna Darley operate, most of the above boxes are ticked.

They are excellent clients, pay their account on time every month, have good facilities, use the services my practice has to offer, and are really well organised. Donna especially is big on protocols and is persistent in getting me to help write the protocols up for their staff to follow. I know that when I see a lame cow, or arrive to do pregnancy tests, that certain basics have already been done. We recently had an issue with the weaner heifers and Donna persevered until we got it sorted by allowing us to call in our local District Vet and a specialist Parasitologist.

I recently attended Dairy Australia's ReproRight course and had no hesitation in asking the Darley's if I could use their herd as a case study. Their system of record keeping is excellent and I had no qualms that would be prepared to work with me to investigate their operation. After analysing the data, we

were able to use it and compare the Conception rates with the various operators. This type of analysis can be a bit confronting for some.

Finally, because we have a strong working relationship, when things go wrong, or there is an error in some aspect of the invoicing etc., Adam is straightforward about making me aware. We resolve the issue and we move on. Disputes are an inevitable part of doing business with someone for over a quarter of a century, and it is important to learn to resolve them agreeably.

# HOLSTEIN TO JERSEY: THE DECISION MAKING PROCESS BEHIND THE CHANGE

**Jamie Drury**

*Farmer, Attunga NSW*

## Operation Overview

The 134ha property “Bonnie Doon” was converted to a dairy operation in 2005. All dairy and irrigation infrastructure has been developed from a greenfield site within the last 12 years. All facilities have been built to the highest industry standard with the ability to expand the operation into the future.

The infrastructure and cropping rotations have been developed in order to provide year round flat supply of high quality milk.



## Irrigation

There are three Valley centre pivots in place:

- 1 x full circle, 7 span, covering 44ha (commissioned 2005)
- 1 x half circle, 7 span, covering 22ha (commissioned 2006 )
- 1 x half circle, 6 span, with end gun covering 22ha (commissioned 2009)



Pivots are fed from two pumps at the river with stainless filters and are fed through 8" mains. Two pivots can be run at once with the whole area able to be watered with 12mm in every 24 hours which covers the maximum daily evaporation rate of 10.5mm using 8M/L per day. The two pond effluent system is injected into the mains through a 4" PVC line after passing through an automatic cleaning stainless steel filter. Effluent is injected at 12% of total volume used. All pivots are equipped for automated fertigation.



### **Infrastructure**

- 30m x 12m machinery shed with three phase power connected.
- 5000L diesel fuel storage with bowser for metering of all fuel usage.
- Hay shed has storage for 260T of hay.
- 4 silage bunkers hold up to 8000T of pit silage. Pits are gravelled for all weather access along with feed mixing area.
- Grain milling complex with Skiold 2500 disc mill, 15T finished product silo, 75T cereal silo and 50T protein meal silo with out-load augers.



### **Cropping**



Crop rotation consists of corn and ryegrass for two to three years and then into Lucerne for three to four years.

Corn crops have consistently yielded 24-25T DM/ha over the last six years. Ryegrass yields have been between 10-14T DM/ha and Lucerne is at 18T DM/ha.

All manure harvested from the dry lots and solids trap is spread in front of corn crops at 12.5t/ha depending on requirements as shown on soil test and expected yields. There have been large amounts of fertiliser used since purchasing the property in 2005 giving a high soil fertility and soil health for good crop yields and quality.



Average water usage over the last twelve years has been 268 megs/year with two years of zero allocation. Crops have been selected on a combination of water use efficiency and ration needs, enabling high yields with less water use.

### **Leased Property**

An 80ha property is also currently leased for rearing heifers and growing feed. This farm has similar soil types with 35ha of irrigation from a Valley lateral irrigator. This property has been run in the same manner as the dairy block. Irrigated areas have similar yields to the dairy block. Some double cropped dry land country on the lease block has averaged 24T DM/ha, with cereal crops yielding 10T DM/ha and dry land corn yielding 14T DM/ha.



### **Dairy**

The dairy is a Bou-Matic double-15 Grand Prix parlour. The feed pad is concrete with headlocks for 300 cows.



## **Production Summary**

Current herd numbers are at 300 Jersey milkers averaging 6000L 5.3% fat and 4% protein. 2015/2016 total production was 155,000 kg milk solids. Target milker numbers are 360 Jerseys year around filling the current 7100L/day premium supply milk contract with Lion Dairy & Drinks.

Cow numbers for 2017/2018 are projected to 330 year round (380 total lactations) to produce 200,000 kg MS, (1830 kg/ha or 530kg MS/cow).

The milking platform is 110ha with 88ha under centre pivots. The cows are grazed on ryegrass from mid-April to mid-December, and on 22ha of kikuyu/white clover pasture through summer.

A PMR is fed all year with no grain feeding in the dairy. All forage for the PMR is home grown. On an average year we harvest:

- 1500t corn silage (22ha)
- 1200t ryegrass silage
- 100t cereal hay
- 300t lucerne hay

We aim for the only purchased feed to be grain and some straw (for the dry cow TMR).

## **DairyBase Figures for 2015/2016**

- Grew 15.3 t DM/ha on the milking area
- Achieved 4.1t/DM forage per cow
- Grazed feed cost came in at \$82 t/DM
- 620mm rainfall to produce 1.2t DM per 100mm and 8.1t/DM per Mg of irrigation
- Our cost of production was \$5.56 kg/MS
- Finance and lease cost was \$1.84 kg/MS (24c is for the lease block)
- Return on Asset of 9.3%
- Return on Equity of 11.8%

## **So Why the Change?**

We could talk all day about the quality of Jersey milk, it has greater nutrient value, better taste, more efficient processing and a lower carbon footprint but I will leave these things to the benefit of the processors and the environment. I want to go through the benefits we have seen and the process we went through making the decision.

This is a decision based on our farm and farming system. The decision will not fit everyone but the process is a valuable and relevant one for all.

## Cost of Freight

There is no doubt that the evolution of milk payment systems over the last 20 years has been to the benefit of Jersey milk. To be paid totally on kilograms of fat and protein with a freight cost on litres, which reflects the real price of milk, is far better than cents per litre which in my mind is a redundant figure. Many people pass comment that I have changed to Jersey's to get better milk price. I'm paid the same price for my milk, I get paid on milk solids, my advantage is a saving on freight.

To make a comparison I'll use our best year for milk solids with Holsteins of 180,000 kg/MS.

For a Holstein herd at 3.8% fat and 3.2% protein (7% solids), that 180,000 kg/MS will take 2.57 million litres of milk.

For a Jersey herd at 5.2% fat and 4.2% protein (9.2% solids) that same 180,000 kg/MS will take 1.95 million litres of milk.

So our freight saving will be  $2.57 - 1.95 = 620,000$  litres. Our freight price for milk is 3.5c/l which is a saving of \$21,700 per year.

This number will only ever get worse as the cost of freight will increase over time.

## The Jersey Efficiency

One of our biggest costs in dairying is our feed base, so doesn't it make common sense to have the most efficient cow to convert that feed into the most income?

Consulting nutritionist James Huffard, who operates a dairy in Virginia, USA, gave the example at the 2014 International Conference of the World Jersey Cattle Bureau: When you take a fixed amount of feed and put that feed through a Jersey cow and a Holstein cow, the Jersey cow produces 22% more income over the Holstein. That feed cost is the same regardless the cow that eats it.



In our operation, a calculation I have used regularly to compare our current production to what we would have had to achieve with our previous Holstein herd, an example is as follows:

Current production for our Jersey cows are 21 litres at 9.5% MS (5.4% f & 4.1% p) = 2.0 kg MS. Our ration currently is 5kg grain, 2kg DM corn silage and as much grass as we can get them to eat.

To convert to Holstein: Holstein cow weighs 750kg, Jersey cow weighs 450kg

$450 / 750 = 0.6$ , a Jersey will eat slightly more DM per kg of Body weight so let's use a conversion of 0.75

So the 2kg/MS the Jersey cow is producing equates to  $2.0 / 0.75 = 2.67$  kg/MS for the Holstein.

For a similar ration of grain, corn silage and grass (given an increase to allow for a larger cow to 5.7kg grain & 2.7 kg corn silage) I will estimate Holstein components at 3.5% fat 3.3% protein (6.8% solids) the Holstein cow will need to produce  $2.67 / 0.68 = 39.2$  litres.

I am confident in saying our Holsteins wouldn't have achieved this on such a ration. She would also need to make up for the extra 63.7 cents freight on her milk.

One difference we have seen with the Jerseys is their ability/preference for eating forage and their ability to utilize lower quality forage if needed and still produce profitably.

### ***Herd Health & Reproduction***

Our breeding program and culling protocol over many years has been hard on herd health and reproduction, but we still weren't performing to the standard I thought we need to be. It felt as though we were continually making management and nutrition changes to address another issue, whether it be conception rates, foot health and mobility, calving ease, heat stress, fat depression in spring and the list goes on.

These issues certainly came into our consideration when assessing the change but we didn't come close to realising how much better the Jerseys would be.

#### *Getting Cows Pregnant*

Our Holstein herd would generally run at 25 to 35% pregnancy rate per service, with periods of stress being much lower, to the point where we didn't mate cows in January due to heat stress.

The Jerseys have been running around 50 to 60% pregnancy's per service, with the lower end of that rate being for January mating's. We have found we needed to be diligent on leaving cows a long enough voluntary waiting period as we were getting a lot of cows hold first service and be re-calving in 11 months.

#### *Calving Ease*

The reputation of calving ease for Jerseys is well earned. Over the last 4 years we have assisted about 0.5% of calving's. The only time we have needed to assist has been for malpresentations such as a dead calf with a head turned back, breech with the legs tucked under etc. It's very nice to be able to sleep at night and not be up checking cows.

#### *Foot Health & Mobility*

The hard black hooves of the Jersey cow and low body weight lead to very few foot health issues. We had a regular hoof trimming program with our Holstein herd along with treating a number of lame cows between visits. We no longer have a hoof trimming program as it's not needed and we probably treat around 10 cows for lameness from abscesses or foot injuries a year. Foot infections treated with penicillin are similar for both.

The other significant difference we see is mobility. Jerseys are in a hurry to get where they are going. We have estimated that we save around \$20,000 per annum in not having to push cows to and from the dairy to paddocks, along with being far more effective with our time.

#### *Fat Depression*

One issue we had, along with it seem every other farmer running Holsteins, were fat depression in winter and spring. At a time of year when we should have been cruising along with cheap grass you find yourself spending money trying to rectify low fat percentage, generally to little effect.

Our Jersey ration in this period is generally 3 to 5 kg of grain, 2 kg DM corn silage and as much grass as we can get them to eat. This maintains a fat percentage of 4.8 to 5%. Fat depression is not a consideration. The other difference we have noticed is that they have a tendency to select for forage hence altering their diet for higher fibre content.

## *Mastitis & SCC*

We have continued the same milking process as we had with the Holstein herd and our SCC has been similar. One difference we have seen is a lower mastitis incidence. We put this down to the fact that because of the lower litres produced there is less pressure and stress on the udder so they are less susceptible to infection.

## **Herd Growth**

Something we always struggled to achieve with our Holsteins was internal herd growth due mainly to lower reproduction rates leading to less heifer calves and a higher involuntary cull rate. Internal herd growth gives greater flexibility in optimising milk production, controlling cost of production, generating additional income through higher value cattle sales and an increasing net worth.

### *A Comparison between Breeds*

Holsteins: cull rate averaged 25% (mostly involuntary), with heifer calf numbers around 120 per year.

Jerseys: cull rate has been at 17% (half involuntary), with heifer numbers around 150 per year.

If we use each cull rate and allow 10% increase for deaths and heifer selection that gives us 35% for Holsteins and 27% for Jerseys. So herd growth will be as follows:

Holstein at 120 heifers can achieve herd growth of 5%, so it will take 14 years to double herd size, or have 15 animals for higher value sales.

Jersey at 150 heifers can achieve a growth rate of 23%, so it will take 4 years to double herd size or have 69 animals available for higher value sales.

This gives you a great flexibility to cull harder, grow numbers, add higher value sales or change calving patterns, however you look at it, it generates profit. This more than compensates for lower cull cow and bobby calf prices.



## **Per Cow Profit**

One thing that we were consistently advised was that there would be a decrease in per cow profit so we would need to milk more cows. This is seen by many as a negative, I think because they think of them as Holsteins. Because of the fact that they are so much better on health and reproduction, mobility and management traits they are far less work than Holsteins. Throughput through the dairy is greater in both number of cows per hour and kilograms of milk solids per hour. Hence the higher numbers of Jerseys pose no extra workload.

Our test budgets were done on milking 360 Jerseys year round compared to 300 Holsteins. We have milked around 300 Jerseys the last couple of years and have found they are more profitable per cow than the Holstein. This is supported by an article in the June 13, 2014 Hoards Dairyman “Brown is the color of Money” by Dennis Halladay.

Below is a table from a data set from Gensk, Mulder & Co LLC, the largest dairy accounting firm in the US, from a summary of all their clients split into Jersey herds and non-Jersey herds.

|                        | <b>All herds</b> | <b>Jerseys</b> |
|------------------------|------------------|----------------|
| Average cows milked    | 2091             | 2036           |
| Average litre/cow/day  | 31.6             | 26             |
| Average fat test       | 3.69%            | 4.47%          |
| Average protein test   | 3.17%            | 3.51%          |
| Total milk solids      | 2.17kg           | 2.07kg         |
| Milk price per litre   | 46 cents         | 51.2 cents     |
| Total income per litre | 47.4 cents       | 52.3 cents     |
| Profit per cow         | \$267            | \$389          |

The bottom line is jersey herds made 45.7% more net profit per cow.

So when we account for the fact we will milk more jerseys compared to Holsteins that makes the profit gap even greater.

## **Conclusions**

We have had some challenges along the way with changing the herd over a period of a year. You definitely need to approach the management of Jerseys in a different way and not to be mentally hobbled by previous experience with Holsteins.

The decision to change to Jersey has undoubtedly been the best business decision we have ever made. It has had a huge positive impact on business efficiency and profitability, and on workload and personal stress.

“We have an animal that is smaller, uses fewer natural resources and produces a smaller carbon footprint. We have a cow with a longer productive life that produces a more nutrient-rich milk that consumers are demanding and will to pay for.” (James Ahlem, past-President, National All-Jersey Inc.)

**The Jersey is the modern day dairy cow and the future of a  
successful dairy industry**

# FUTURE MEGATRENDS AND VALUE CHAINS –AUSTRALIAN AGRICULTURE IN THE SPOTLIGHT

**Steve Crimp**

CSIRO

## Background

CSIRO's *National Outlook* is a ground-breaking attempt to model and analyse Australia's physical economy and natural resource use many decades into the future.

It focuses on the emerging water-energy-food nexus, and the prospects for Australia's energy, agriculture, and other material intensive industries in the context of multiple uncertainties and opportunities. For further information please visit

<https://www.csiro.au/en/Research/Major-initiatives/Australian-National-Outlook/National-Outlook-publications/Main-reports>

## Future scenarios

The *National Outlook* comprises many scenarios, but highlights four spanning a range of feasible Australian futures. Each scenario depends on a specific global context. Each assumes set-and-forget Australian policies and bottom-up trends, as opposed to scenarios that are revised as our expectations are updated by events and changing circumstances. Each scenario takes a different path and gets to a different point by 2050. The modelling approach has an in-built conservative tendency, in that it does not and cannot anticipate the game-changing technologies and surprising "black swan" events that, while inevitable as time unfolds, are unpredictable.

## KEY MESSAGES AND FINDINGS

Australia has the capacity to pursue economic growth, sustainable resource use and reduced environmental pressures simultaneously. Policies and institutions will be essential to realise Australia's full potential and manage the associated trade-offs and risks.

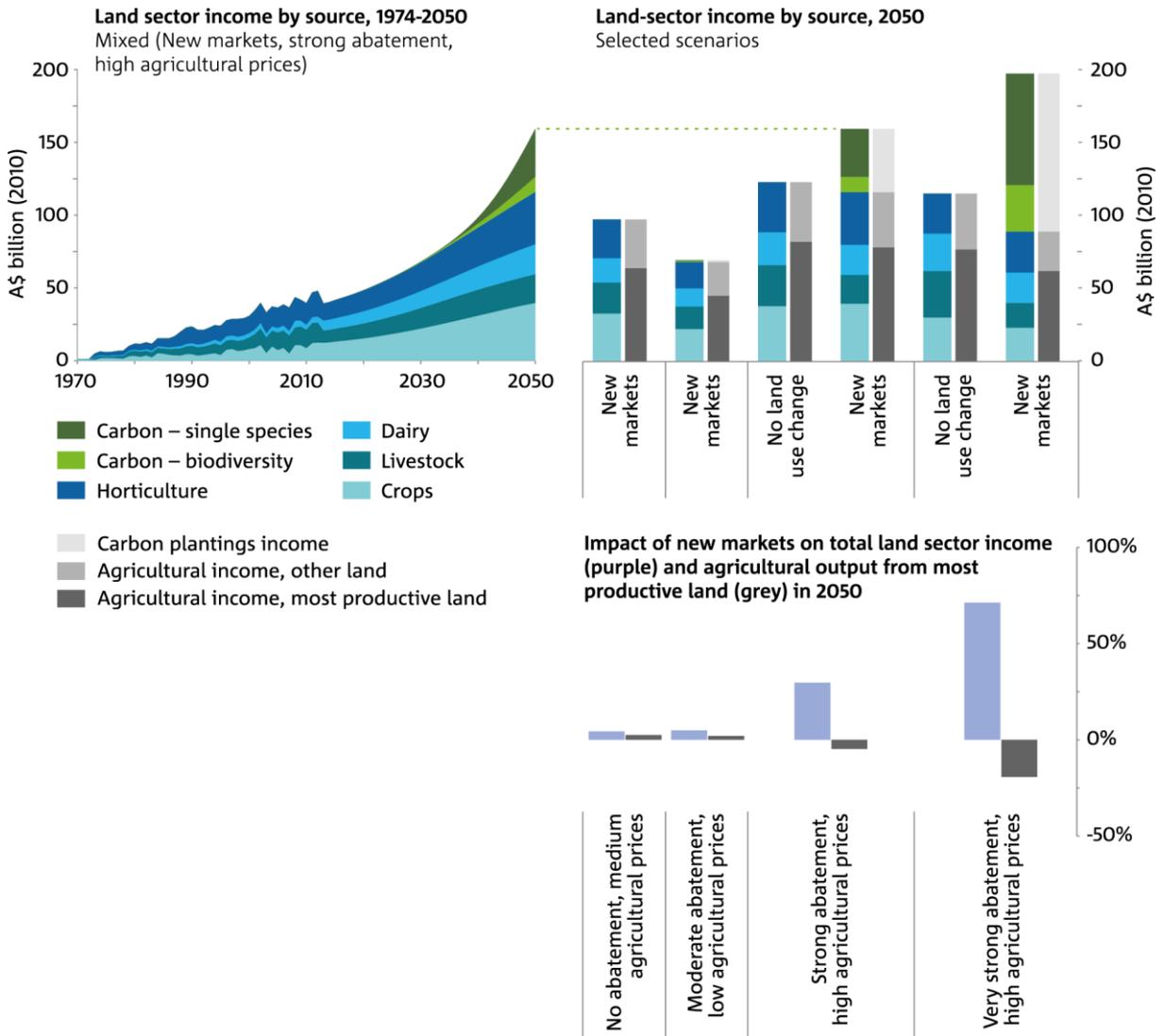
**Australia's choices will shape our prosperity. Agility, innovation and productivity will be vital to make the most of a positive – but uncertain – global economic outlook.**

Global demand for Australia's exports is projected to treble through to 2050 as global per capita income also trebles. While we can be confident in some high level trends, such as long term growth of world energy and food demand, the risks and opportunities facing specific sectors of our economy are less certain. Demand for specific materials and energy exports will vary with international developments. Flexibility in the deployment of its natural and institutional resources will be needed for Australia to prosper across a diverse range of global scenarios.

Agricultural export prices are likely to trend upwards over coming decades reversing a long historical decline (Figure 1). Our analysis shows that Australia's total output of food and fibre can increase – even in scenarios with significant shifts of land out of agriculture – if agricultural productivity growth is restored. However, we have not fully explored the complex distributional implications of these scenarios, and we do not yet fully understand the potential cascading impacts of future climate change

and extreme events on farms, sectors, and regions. The scale and multiple complexities of these potential changes could raise unprecedented challenges for landowners and regional communities.

The future of our nation, industries and communities will depend on how we position for change, and adapt as the world around us evolves. In most cases, innovation and improving productivity are no regret moves that will help to create a better future.



Shows the projected value of agricultural crops, livestock, dairy and horticulture output, and the value payments for carbon and biodiversity plantings, accounting for projected changes in land use in the intensive-use zone. The left hand panel shows the projections to 2050 with strong abatement incentives, along with historical data from 1974 to 2012. Historical data shown also includes the extensive land-use zone which is a significant share of national livestock output. The right hand panel shows percentage change in land sector incomes in 2050 attributable to new land sector markets (purple), and the percentage impact of new markets on the value of agricultural output from 'most productive land' (grey). Most productive land is defined for this purpose as the area that accounts for two thirds of the value of output in 2010 for each of 20 agricultural commodities modelled in LUTO, totalling one third (36%) of the area of agricultural land in the intensive use zone. Results assume trend agricultural productivity and a balanced approach to carbon and biodiversity, across different levels of abatement effort, with and without new markets.

Source: Historical data from ABARES (2013); prices from GIAM; and, volumes and spatial details from LUTO

## **Sustainability and economic growth can be partners not competitors.**

The *National Outlook* analysis suggests that Australia can achieve economic growth and improved living standards while also protecting or even improving its' natural assets. However this will not happen automatically. Australia's economy is projected to treble by 2050, while national income per person increases by 12 to 15% above inflation per decade (assuming no major shocks) – with different choices about working hours accounting for two-thirds of the range of projected outcomes.

Energy and transport can remain affordable, with energy efficiency offsetting higher prices for electricity and fuel (including in low carbon scenarios), and better management of peak demand and improved electricity network operations and investment discipline could deliver further benefits. By 2050, electric vehicles and biofuels could reverse our mounting transport fuel imports, as well as reducing costs, improving air quality, and reducing greenhouse gas emissions.

Business, individuals, and government all need to be involved in lifting productivity and enhancing our shared social, economic and natural capital. Efficient and responsive institutional settings can turn challenges into opportunities, and have a vital role in managing trade-offs and promoting longer term sustainability and prosperity.

## **Decisions we make as a society matter – and will shape Australia's future more than decisions we make as businesses or individuals.**

Policies and institutions are central to unlocking potential benefits and managing trade-offs and risks. Collective decisions account for 50-90% of the differences in resource use and natural assets across the scenarios in the *National Outlook*, resulting in synergies in some cases and trade-offs in others. Institutional settings are crucial to support the deployment of existing and new technologies that match our economic and environmental aspirations in energy, water, transport, agriculture and other industries.

Managing the water-energy-food nexus will produce challenges and opportunities for rural land use and communities. We can transform and enrich our economy and regional communities by meeting national and global food, fibre, energy, carbon sequestration, and conservation needs through new land sector markets, if we manage these transitions well.

While water use is projected to double by 2050, this growth can be met while enhancing urban water security and avoiding increased environmental pressures through increased water recycling, desalination and integrated catchment management. We find water demand and supply are shaped by complex interactions between food production, energy-intensive industries, energy and water efficiency, and new carbon plantings – all against a background of regional constraints on rain-fed water resources and a growing population and economy.

We can reduce our greenhouse gas emissions significantly through energy efficiency, carbon capture and storage, renewable energy, and land-sector sequestration. In the case of concerted global action on climate change, this could see Australia reduce its per capita emissions to below the global average by 2050, down from five times the average in 1990, while maintaining strong economic growth. Actual costs and benefits would be highly dependent on the details of domestic policies, and how these interact with international actions.

We find that sustainable resource use and economic growth can be partners not competitors. Australia has the technology to pursue both at the same time, and with sound policies and institutions, can benefit from the positive outlook for its living standards, natural resources, and environmental assets.

## **Implications for Australian Agricultural Value Chains**

Recent experience with extreme weather highlights business exposure to climate change. The task of governing climate adaptation not only lies in the public domain, but likewise within the private sector. As businesses respond to increasing opportunities in global supply and demand, the direct and indirect impacts of climate change will be increasingly felt across scales of operations. Various degrees of adaptation are required at multiple points across the business value chain, creating opportunities for mainstreaming systemic and possibly transformational adaptation.

However, not every business is effective at adapting to changing climate risks. The overwhelming barrier to adaptation is commonly identified as lack of understanding of the impacts of climate change on business bottom line. In this presentation we will highlight an approach to understanding climate change in the context of existing business practise.

## **References**

Hatfield-Dodds S, McKellar L, Brinsmead TS, Bryan BA, Graham P, *et al.*, (2015) *Australian National Outlook 2015 – Technical Report: Economic activity, resource use, environmental performance and living standards, 1970–2050*, CSIRO, Canberra.



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**Contact numbers:**

Tim Wirth - National - 0402 078 659

Ron Arnold - Northern NSW - 0409 329 464

Phil Monaghan - Southern NSW - 0428 946 268

Andrew Schumetzer - VIC - 0427 781 706

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# OPTIONS FOR MANAGING HEAT STRESS

## Neil Moss

*Dr Neil Moss BVSc PhD Dip VetClinStud Dip HRM (Dairy)*

*Scibus (www.scibus.com.au)*

*2 Broughton St Camden NSW 2570*

*nmoss@scibus.com.au*

*0412 558532*

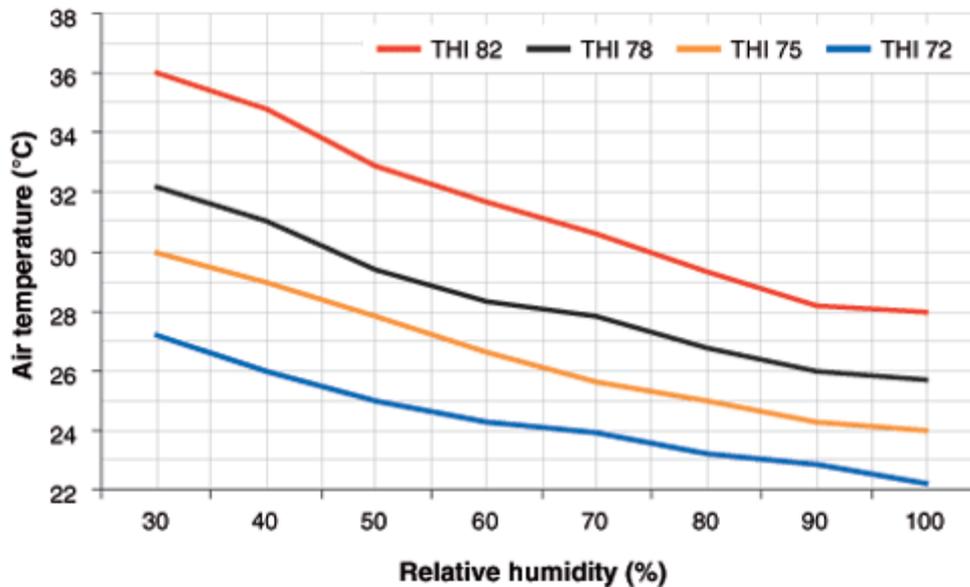
The summer of 2016-17 has been widely reported by most farmers as being the hottest and most challenging in recent memory. Combined impacts of extreme temperatures and very high humidity, often for multiple consecutive days, and very warm night temperatures that failed to allow cow to shed heat significantly impacted both milk production and milk quality (components and somatic cell count) as well as animal health and reproductive problems. In some areas, multiple deaths in cattle occurred due to extremes in temperature and humidity, often in combination with other underlying health problems in those individual cows affected.

In more “normal” seasons, drops in summer milk production of 10-15% compared to spring level are standard and highly predictable based on reductions in dry matter intake due to heat stress, reductions in pasture quality driven by increasing levels in NDF (and sometimes protein) and increase in energetic demands from cows as energetically expensive heat stress control mechanisms such as panting and sweating are activated. This can easily account for reductions in available energy for milk production of 20-30 megajoules or the equivalent of between 4 and 6 litres per cow. Early in summer, this energetic deficit is not fully expressed as most cows will compensate to a degree with mobilisation of body tissue (if available) and lower humidity levels prior to Christmas tend to allow cows in coastal regions to better manage heat stress with sweating or panting. Peak losses tend to manifest as herds move into late January and through the most humid months of February and early March. This summer, milk production in many herds during the peak heat stress periods was depressed by up to 40% when compared to end of spring levels.

Temperature Heat Index (THI) is a measure used to estimate the combined impacts of heat and humidity. In brief:

- When the THI exceeds 72, cows are likely to begin experiencing heat stress and their incalf rates will be affected.
- When the THI exceeds 78, cows milk production is seriously affected.
- When the THI rises above 82, very significant losses in milk production are likely, cows show signs of severe stress and may ultimately die.

(Source: Dairy Australia Cool Cows Website : <http://www.coolcows.com.au/go-on-alert/thi.htm>)



In reviewing the temperature and humidity extremes of the previous summer, it can be clearly seen that there were multiple days where the THI in most dairying regions exceeded the threshold of 82, generally considered as extreme and that much of the summer was spent at a level exceeding a THI of 75. All herds will have been impacted to some degree by this. Importantly, however, there is significant variation between herds within regions in how milk production and animal health was impacted by heat stress and elevated THI. While localised microclimate variation may have played a role in this, differences between individual farms heat stress management did have a profound impact on how cows' and herds' production, health and fertility were affected by the highly predictable and continuing challenges that heat stress will present to the NSW and broader Australian dairy industry in years to come. Dairy Australia through its Cool Cows program (<http://www.coolcows.com.au/>) has developed some excellent resources for farmers that assist with designing strategies for managing heat stress. This should be essential reading for all Australian dairy farms. The following paper summarizes some of the management tactics and strategies that we are seeing be successfully utilised on our client's (and many other) farms to assist with heat stress management today.

### 1. Modify milking times.

Grazing cows intake of pasture in summer is significantly impacted by THI, particularly during daylight hours. Normal patterns of day grazing see cows consume the bulk of their forage immediately on reaching pasture followed by a period of rest and cud chewing. During mid-morning most cows will get up and commence grazing again. Under summer conditions, cows are frequently observed to be seeking shade by as early as 9am. This can greatly impact cows ability to consume adequate pasture. Late or protracted morning milkings where cows do not get to the paddock with at least 3-4 hours of potential grazing before THI rises to > 72C will impact intake. Working with staff to have morning milkings occur as early as possible will maximise morning intake of pasture. Other strategies can be utilised to increase late mornings intake (see later).

Selection of afternoon milking time can also impact cattle performance under elevated THI conditions. On farms where there is a lack of paddock shade, and if dairy facilities are set up with adequate shade and sprinkler systems for cooling cows, bringing cows to the parlour earlier for milking or even to stand and escape the direct sun can effectively reduce cattle heat load, particularly in conditions where humidity is lower and evaporative cooling is favoured. At times, earlier afternoon milking can be considered if wet cows can then go out to cool in breezy conditions or if humidity is lower. Importantly, under extreme THI with very high humidity, and if labour structures allow flexibility, it can be advisable to delay milking till early evening (after 5pm) to reduce the combined impact of walking under these conditions and peak mid-afternoon temperatures. At these times, particularly if coinciding

with very still conditions, heat load can rapidly increase and cows may be better left undisturbed if they have shade available in the areas they are resting in.

#### **Key points**

- ***Work with staff to milk as early as possible in the morning***
- ***Rapidly get cows to pasture if grazing or other feed***
- ***Vary afternoon milking based on facilities and conditions***
- ***Be prepared to milk after 5pm in extreme conditions***
- ***Be patient with walking cows in afternoon heat***

## **2. Bring feed during the day to cows sheltering from the heat**

Most high producing cows at pasture will seek additional feed after a period of rest following their initial grazing after morning milking. Under high THI conditions, dairy cows will seek shade early and will often leave the paddock to areas with shade and water if these are not available near where they are grazing. Generally, the cows desire to attempt to stay cool will take precedent of her need to continue feeding and cows will not voluntarily leave shade or return to the paddock in the late morning even if there is abundant high-quality pasture available. Similarly, TMR or PMR systems where cows are expected to eat all their day feed immediately after morning milking in a 1-2 hour period and then see them move off to shade that is distant from the feedpad (NB if uncovered), will see very few cows venture back to the feedpad to consume additional feed during the middle of the day as they may in cooler months. Likely intake deficits during this time will be between 2-4 kgs of dry matter.

**Under these conditions intake can be significantly improved if feed is taken to the areas where the cows are resting.** This can be provided in the form of either silages or hay presented in feed racks or additional TMR in portable troughs. Early and peak lactation cows in particular benefit from this, allowing them to continue consuming forage during the day as would be normal behaviour at cooler times of year or if housed. Critically, this forage must be of very high quality and palatability to encourage intake, minimise wastage and to maximise potential milk production returns. Competition will be much less at feed stations when compared to systems that feed all forage through feed racks so the number of racks and feed offered generally does not need to exceed 1 rack per 50 cows.

An alternative strategy that has been successfully employed on farms with pivot irrigation has been to allow cows to shelter under sprinklers in the paddock while feeding additional hay out on the ground or in nearby portable racks. While feeding on the ground may increase wastage, cows will proceed to walk out of the sprinkler areas, consume some forage and then return to the cool of the sprinklers once again rotating through this multiple times through the morning and early afternoon. Importantly, pasture composition needs to be relatively robust as this can result in significant pugging damage if paddocks get saturated in the areas where cows are sheltering under sprinklers.

#### **Key points**

- ***Ensure cows have access to shade during the heat of the day***
- ***Provide supplementary forage in or near shade or bring cows back to PMR rations during the day if cows can be cooled to support additional dry matter intake***
- ***Ensure forage is high quality and palatable to encourage intake***
- ***Ensure feed and water is close to shade so cows can easily access when sheltering from heat***

### 3. Sprinklers, shade and fans in the dairy

Provision of a sprinkler system enhanced if possible with provision of shade over the dairy yard is a must for nearly all mainland dairy farms. Under heat stress conditions Davidson *et al* (2016) demonstrated a greater than 5% improvement in production if either shade or sprinkler systems were provided at day milking. This improvement exceeded 10% if both were provided simultaneously. Increasingly fans are being installed in both dairy sheds and other covered areas to further augment cooling and dissipation of heat. This work is supported by abundant international research and anecdotal observation by Australian farms. Critically sprinkler systems should:

- *deliver large droplets of water rather than mists in the dairy yard. Misting systems will humidify the air and can compound THI and humidity*
- *be used to wet down and cool concrete in unshaded yards before cows arrive at the dairy*
- *be set up with timers that after an initial wetting phase of 8-10 minutes to wet cows, come on for 2-3 minutes then be switched off for 5-6 minutes to allow evaporative cooling (NB when humidity is low). When humidity is very high, longer wetting phases may be appropriate as conductive rather than evaporative cooling can be important and useful if water temperatures are significantly lower than environmental temperatures. Systems with very small droplets or that are prone to misting can exacerbate heat stress under very humid conditions.*
- *be used in the morning as well as the afternoon. Wetting and cooling cows in the morning will aid with heat loss when night temperatures have failed to drop below 22 C and will also keep cows cooler into the morning as they move to feed or graze encouraging them to eat for longer before seeking shade mid-morning.*

### 4. Ensure adequacy of water supply

Cows must have access to abundant clean, non-saline water at all times. Cows can consume between 200 and 250 litres per day and is important as both a nutrient and as a means of directly cooling cows through conduction. Water loss from cows increases in summer from panting, sweating, drooling and can be increased in urine and feces in higher sodium diets. Increased water intake encourages rumen outflow and dry matter intake. Cows can consume up to 30% of the water intake as they leave the dairy and if being supplemented with salt, will be even more highly stimulated to seek water. Troughs should have sufficient functional reserve and flow rate to maintain volume for all cows to be able to drink as they exit. Cows can drink at over 15 L per minute and as such, water trough design and water pumping systems should consider herd size and flow of cattle from the dairy after milking. Ten cows drinking at once will remove up to 150 litres of water per minute and lower volume troughs must account for this with very high flow rates. Review of trough size and access and water flow rates is important if herd size has increased.

Water troughs should be installed in **every grazing paddock** to encourage water consumption at pasture and to encourage maximum pasture consumption. Once cows leave a paddock in summer to seek water, they will seldom return, even if high quality pasture is still available.

Water should also be provided in all **loafing or sheltering areas** and on feedpads and shade sheds but careful management and design of troughs to prevent spilling and soiling in trough areas is important to reduce impact of flies, to prevent lying in mud and to reduce risk of environmental mastitis.

#### **Key points**

- *Abundant cool clean water is critical for both heat loss and metabolic function*
- *Water supply and pumping budgets need to provide for 200-250 litres of water per day with 30-40% provided immediately post milking*

- *Water troughs should be in every grazing paddock and all shade/loafing/feeding areas*
- *Design and maintain troughs to prevent leakage and overflow and accumulation of feces, urine and mud*

*From a management perspective:*

- *trough function and refilling must be checked twice daily during hot weather*
- *if troughs are seen to regularly run empty when cows are drinking, review flow rates*
- *troughs should be checked for cleanliness regularly*
- *stock handlers need to exercise patience with drinking cattle and allow them to fill when moving herds. Cows can take 2-3 minutes to consume adequate amounts of water*

## 5. Pasture planning and grazing management

Summer pastures must be managed for quality and palatability to maximise intake and nutrient density during summer. Both temperate and sub-tropical grass based pastures and forage crops will be prone to develop excessive levels of neutral detergent fibre (NDF) with this fibre becoming decreasingly digestible. Increased forage NDF levels result in reduced intake and palatability as well as simultaneous reductions in both non-structural carbohydrates (most importantly sugars) and protein. As summer conditions greatly favour growth of subtropical species such as kikuyu and paspalum, particularly once summer rainfall commences from mid-January onwards in coastal regions, it is common to reduce nitrogen fertiliser inputs as there is “plenty of pasture”. This has the effect of further reducing forage quality. Pastures and grazing forage crops can rapidly get out of control with growth rates exceeding 100 and approaching up to 200 kg dm/ha per day. At this time attempts to manage them with grazing cattle only will generally result in ever decreasing pasture quality and intake. This issue can be further exacerbated when more palatable grasses such as kikuyu or paspalum are outcompeted by invasive annual summer grasses such as pigeon grass, crab and goose grasses creating false impression of available high-quality pastures. Producers should consider the following:

- Be prepared to speed up grazing rotation to graze pastures at optimum height (15-20cm of **available** pasture if kikuyu or paspalum based). This may result in rotations of as short as 8-10 days
- Be prepared to “skip” paddocks that are getting ahead of the cows and consider conserving this forage.
- Be cautious of using cows to “eat down” lower quality residuals and be prepared to manage this with topping/slashing/mulching. Forcing cows to eat into the base of summer pastures to assist with pasture management and minimise the need to mechanical control residuals, will **turn down milk production** as the cows, by definition, need to be very hungry to eat that hard. This is very different situation to good-quality cooler season pastures where overgrazing needs to be managed very carefully.
- Maintain good levels of fertility- NB nitrogen. Fertiliser should be considered as a means of controlling pasture quality as well as quantity. Under similar growing conditions, crude protein and NDF levels of unfertilised and fertilised kikuyu pastures can vary between 14 and 30% CP and 40 and 60% NDF respectively
- Manage pastures to minimise invasion with annual summer grass weeds.

- Carefully assess pasture composition, particularly when there appears to be substantial pasture rejection. This may be due to a high prevalence of invasive annual grasses such as crab or crowsfoot grasses or couch. Forcing cows to eat these will reduce milk production
- Pre-mowing of summer forages can increase intake and the amount of forage that cattle can quickly consume before temperatures rise and cows leave the paddock. It is also an effective method of weed and residual control.
- Consider alternate uses for paddocks that grow predominantly summer grasses. This could involve conversion to other more palatable summer pasture species (legume and herb blends), summer cropping for grazing or conservation (maize, sorghum, millet, brassicas legume crops), summer fallowing for early sowing of annual autumn pastures or strategic fallowing as part of preparation for improved perennial temperate species or kikuyu restoration.
- Select summer grazing crops for quality and digestibility. Consider BMR hybrids if using sorghums. Ensure flowering dates are compatible with your needs for the crop. Generally use later flowering hybrids if multiple grazings are required.

Use millets or shorter season hybrids if fewer grazings are needed and early conversion back to winter forages is planned. Consider use of brassicas in summer in areas where suitable but match maturation times with how quickly you need the feed. Leafy turnip hybrids will generally be more rapid to first grazing and are suitable for irrigation systems or higher rainfall areas where rapes are slower to mature but are much more tolerant to drought once their tap-root is into the subsoil.

- Consider use of legume herb blends as part of a pasture portfolio. These provide the most nutritious pastures through summer and are generally highly palatable. Based on combinations of chicory, plantain, Lucerne and red and white clovers, they also provide options with respect to grass weed control while also demonstrating excellent growth rates coupled with high utilisation. Importantly, when planning pastures, sufficient area to provide a full feed each day for the herd in a continuous rotation is important for maintaining rumen stability. Specialist advice should be sought on their establishment and management of these pastures.

The nutritional composition, compared to well fertilised late season ryegrass and mid-season kikuyu from some of our own trials in Jamberoo, NSW is set out in the table below. Importantly, our anecdotal observation of herds that have had access to these low NDF, highly digestible pastures reported improved intakes and productivity during summer compared to herds with access to good (or mixed) quality grass based pastures only.

**Table 1: Comparison between legume/herb pastures and late season ryegrass and kikuyu in Jamberoo, NSW**

| <b>Components:</b>  | <b>Nov legume herb</b> | <b>Nov ryegrass</b> | <b>Feb legume/herb</b> | <b>Feb kikuyu</b> |
|---------------------|------------------------|---------------------|------------------------|-------------------|
| % NDF               | 30.7                   | 46.3                | 30.4                   | 51.4              |
| % Crude Protein     | 32                     | 24.1                | 33.1                   | 27.5              |
| % Ash               | 13.33                  | 11.34               | 11.35                  | 10.41             |
| Lignin % NDF        | 12.4                   | 3.9                 | 16.8                   | 5.6               |
| % Calcium           | 1.23                   | 0.58                | 1.37                   | 0.53              |
| % Phosphorus        | 0.45                   | 0.42                | 0.45                   | 0.43              |
| % Magnesium         | 0.36                   | 0.3                 | 0.36                   | 0.26              |
| % Potassium         | 3.28                   | 3.13                | 3.18                   | 3.16              |
| % ADF               | 23.6                   | 26.3                | 23.1                   | 26.7              |
| % Lignin            | 3.8                    | 1.8                 | 5.1                    | 2.9               |
| % NFC               | 25.2                   | 18.6                | 27.6                   | 14.4              |
| Relative Feed Value | 214                    | 138                 | 217                    | 123               |
| ME (MJ/kg)          | 11.63                  | 10.8                | 11.76                  | 10.97             |
| ME CPM (MJ/kg DM)*  |                        |                     | 10.16                  | 8.58              |

\* refers to energy density when remodelled with other ingredients using CPM dairy nutritional software

**Key points**

- **Maintain pasture quality by adjusting rotation length and keeping up fertility**
- **Be prepared to mechanically remove pasture residuals**
- **Low quality summer pastures may be a cheap feed but forcing cows to eat them may not always be the most profitable option**
- **Consider cutting paddocks for hay or silage if they get beyond optimum grazing length**

- *Select high digestibility cultivars of grazing forage crops. Digestibility is generally more important than yield in these crops. Consider the role of brassicas depending on region*
- *Consider pre-mowing of summer forages and pastures to encourage rapid intake and manipulate residual quality*
- *Consider legume herb blends for optimal summer feed quality and summer grass control*

## **6. Review the merits of day grazing but focus on forage quality when supplementing or replacing grazing**

Forage intake will generally be the first element of most non-TMR diets to be compromised under heat stress. This will manifest as either reduced pasture intake or reductions in intake of supplementary forages. To optimise total forage intake and complement concentrate feeding, some producers are opting for avoiding day time grazing all together or allow the herd to have only limited controlled access to pasture early in the morning after milking and then bringing the herd to shade facilities or treed areas to be given additional forage. To encourage intake it is critical that the forage fed is of the highest quality and is highly palatable and free of moulds or spoilage. The spring of 2016 in NSW saw very large hay yields. However, this was also coupled with delayed harvests due to wet conditions in inland NSW. The availability of abundant hay offset some of the supply challenges on the coast with what was a more challenging spring with reduced conservation of spring silages. However, the large hay yields and often delayed cutting or protracted drying and baling conditions resulted in much of the hay being very high in NDF with this NDF having very low rumen digestibility. This was not restricted to the cereal hays with much of the Lucerne and clover hay being poorly digestible. Feed testing of forages prior to purchase of forages to be fed of summer is essential. Poorly digestible forages result in reduced intake of summer due to both reduced palatability and slower rumen flow rates. This combined with reduced energy and protein density decreases both milk volumes and milk protein production.

### **Key points**

- *Feed test all forages prior to purchase*
- *Select legumes hays with NDF < 40% and cereals < 55% if available*
- *Titrate feeding of forages to what is consumed on a daily basis to keep forages fresh and free of mould or rain spoilage*
- *Consider use of best ryegrass silage or other home-grown forages in summer to maintain intake and support milk volume and protein*
- *If facilities are present, review if grazing at day time is the best option in summer*

## **7. Adjust concentrate feeding but manage fermentation and acidosis risk carefully**

Increasing the energy density and protein quality of diets is a valuable tool for optimising dry matter intake and maximising intake of energy and protein when dry matter intake is reduced. While maximising pasture and forage quality is important here, the reality of most non-TMR farming systems results generally sees lower summer forage (higher NDF, lower ME, lower NFC, lower CP) quality than in cooler months. Careful concentrate manipulation can offset some of these deficiencies.

Skilful manipulation of concentrates can allow for up to 60% of total dry matter intake to be provided in this form though ranges between 40 and 50% are more common. Concentrates can be delivered either totally through the dairy feeding system or where possible, as part of a mixed ration. Nutritional

support should be sought when concentrate feeding exceed 40% of dry matter intake as risk of dietary disruption and rumen imbalance is greatly exacerbated at these levels, particularly when forage intake may be compromised during heat stress.

NSW dairy farmers generally have access to a range of cereal grain (wheat, triticale and barley) and protein (canola, cottonseed and soy meals) feeding options. Traditional sources of rumen degradable protein and non-starch carbohydrate sources such as lupins, and the recent increased availability of dried distillers grain (DDG) and other low starch concentrates such as millrun provide options for utilising both high quality protein and energy from slower fermenting carbohydrate sources greatly enhancing the function and safety of diets based on winter cereal grains alone. Inclusion of slower fermenting starch sources such as maize or heat-treated sorghum (via pellets) allow formulation of diets that supply a more even source of carbohydrates to rumen micro-organisms and “by-pass” starch and other carbohydrates that can be digested in the intestines and converted more directly to glucose for use by the cow. These also reduce risk of acidosis by slowing and reducing the fall in rumen pH after feeding.

Improvements in home milling options provided by more advanced Disc-Mill and mixing systems, or alternatively, alignment of producers with feed suppliers that are willing to consider custom mixing options using some of these raw materials provides increased flexibility, safety and feed conversion efficiency.

Thorough knowledge of the forage base is essential when formulating concentrate rations. Forage testing services that provide improved estimates of protein and carbohydrate and fibre fractions are now readily available allowing better estimates of potential production and accurate complementary feeding with concentrates. Multiple protein sources may be required, particularly when conserved forage quality is compromised. Use of urea as a non-protein nitrogen source may also be appropriate in conjunction with careful ration formulation and on farm training.

As NDF and NDF digestibility levels deteriorate in feeds and energy and crude protein and protein quality decline:

- ensure adequacy of rumen available protein/nitrogen and carbohydrate based energy (to feed and grow rumen microbes)
- provide higher levels of adequate high-quality bypass protein to assist in supply essential amino acids to the intestines offsetting reduced microbial protein production.

In combination this can assist with milk protein and volume, and stimulation of appetite.

Total dietary protein supply needs to consider how diets are delivered. For example, if all pasture (generally with moderate to higher levels of protein) is fed at night, and the diet fed during the day is based on conserved forages, the total diet across a 24-hour period may appear to provide adequate protein levels (17-19% on a DM basis). However, relative asynchrony in delivery of much of the total dietary protein may result in a relative deficiency of rumen available protein in particular, during the feed when cows are off pasture. Adjustments to dairy or PMR rations to increase supply of protein in synchrony with the non-pasture feed may be important to assist in rumen utilisation of conserved forages.

Feeding of supplementary fats can be considered to increase energy density of summer rations. Energy derived from fats does not add to the heat load of the cow as it does not go through fermentation. Non-bypass fat sources can be considered to increase up to lift the total dietary fat to between 3-4 % of dry matter. Beyond this, bypass fat sources should be considered and can be used in high producing cows to increase dietary fat to 5-6% of total dry matter. It is important to consider positive impacts on reproductive performance of fats as well as their impact on milk volume and components when assessing their cost benefit in rations.

## Key points

- *Use feed test knowledge of pastures and forages to design concentrate strategy*
- *Up to 60% of diet DM can be provided as concentrates if facilities allow and formulation is appropriate. As feeding levels increase, non-starch and slow fermenting carbohydrate sources become more important*
- *Carefully manage acidosis risk with forage delivery systems, use of slow fermenting and non-starch CHO sources, buffering and rumen modifiers*
- *If possible, mix some of concentrates with forages if feeding >40% of DM as concentrate*
- *Ensure both rumen degradable and bypass proteins are met. This is increasingly important as forage quality declines.*
- *Consider delivery systems and timing of offer of different components of the diet when designing rations. Higher than normal total protein levels may be required to balance diets that only feed pasture once a day if conserved forage protein levels are less than pasture levels*
- *Consider the role of supplementary dietary fats, particularly in higher producing herds/cows and in higher milk price environments*

## 8. Feeding bicarb (and other additives where appropriate)

The cows' natural rumen buffering mechanisms rely on production of up to 2.5 kgs a day of bicarbonate in their saliva. During summer, bicarb is lost in both sweat and, under extreme conditions, through salivation and drooling. Significant potassium and sodium is also lost in sweat and through urine. With forage intake more likely to be reduced than concentrate intake and reductions rumination and cud chewing being likely, supplementing bicarb, sodium and potassium (depending on base dietary levels) can help offset increased bicarb and sodium and potassium losses and assist with rumen buffering. Formulating **milking cow** diets to have a positive dietary-cation balance of 25 to 30 mEq/100 g DM DCAD will assist with optimising intake and production needs during heat stress. Sodium bicarbonate has been most commonly used to assist with buffering but potassium bicarbonate can also be considered if total dietary potassium is less than 1.6% DM. These ingredients will also increase diet DCAD. Sodium bicarbonate and additional salt should be considered on legume based or kikuyu diets. Potassium bicarbonate may have a role in diets based on maize silage or cereal forages where forage potassium levels may be less than 1.5% DM. Forage testing and diet analysis are important selecting appropriate methods of bicarb and mineral supplementation. Wet-chemistry mineral testing of forages is important if accurate diet mineral formulation is desired.

### Other additives to consider in summer include:

Rumen modifiers such as monensin, tylosin, virginiamycin, lasalocid and flavomycin can be important in reducing risk of lactic acidosis. Yeasts and yeast extracts may also support rumen function. Risk of lactic acidosis increase in summer, particularly in component diets where forages and grains are fed separately as forage intake will decrease at a greater rate than concentrate intake. Cows on higher levels of concentrate are at much greater risk and additional bicarb may not be sufficient alone to adequately reduce risk of acidosis. Rumen modifiers can also beneficially alter the balance between the different populations of microbes in the rumen and the proportions of VFAs (volatile fatty acids) they produce and improve feed conversion efficiency and reduce risk of ketosis. Requirement for rumen modification of diets will be variable between enterprises and should be carefully reviewed with appropriate nutritional and prescribing advice.

Specific use during heat stress of other additives such as niacin and betaine is variably supported by literature with additional research required to support positive anecdotal results frequently reported from their use. Cautious extrapolation of TMR based feeding trials to Australian non-TMR feeding conditions is advised.

### **Key points**

- ***Consider use of sodium or potassium bicarb in summer rations- role in buffering and replacement of ongoing losses***
- ***Source of bicarb (Na or K) is important and can be matched to forage type and underlying diet macro mineral levels***
- ***Consider increased salt provision and ad-lib access in troughs near water points***
- ***Summer milking diets should be formulated for positive DCAD 25 to 30 mEq/100 g DM***
- ***Review use of antimicrobial and yeast based rumen modifiers in light of acidosis risk and improvements in DMI and FCE***
- ***Betaine and niacin responses may occur in some herds but more research is required***

## **9. Manipulation of calving pattern**

The reality of feeding and managing dairy cows through summer, particularly if in predominantly pasture based systems should consider the following:

- Review by this author of over 10,000 lactation records from different regions in NSW over a 5-year period indicates that per cow production is optimised in cows calved between late February to mid-September. This will be associated with depressive impacts on transition and peak production cows calving outside as well as these cows being exposed to a much higher proportion of their days feeding to either lower quality pastures or conserved forages in the presence of heat stress. This appears highly repeatable between years. Some farms with improved heat management systems may have higher production levels in cows calved outside these months.
- Grazed forages tend to be of highest quality between April and November in most regions with peak availability from August to November. Improvement and innovation in autumn and winter agronomic management can greatly increase availability of high quality pastures between mid-April and through winter
- Water use efficiency for grazed pastures in irrigation areas is optimised between April and November in most regions. Crops such as maize for conservation have high water efficiency in summer
- Many regions in NSW will be seasonally dry between November and late January reducing probability of good dryland pasture supply and quality at that time of year in dryland or mixed grazing systems. This will vary between years and regions. As such, there will often be increased labour and supplementary feeding costs through summer if pasture-reliant systems fail.
- Persistence of perennial rye grass pastures in regions such as Bega in both irrigation and dryland will be favoured when grazing pressure can be reduced over summer.

- Cows that calve between September and January will be exposed to substantial heat stress that will impact both peak productivity and reproductive performance delaying return to pregnancy. Conception rates in cows calved in late spring and mated over mid-summer can drop to < 25%.
- Cows calving over summer are more prone to peri-parturient disease
- Pay rates for year round milk supply that mirror pay rates in seasonal calving regions may fail to acknowledge the increased costs of milk production across summer months. Current summer pay rates from the highest paying milk companies partially acknowledge this but still may not fully offset costs, efforts and losses from chasing summer milk
- Calves born in summer months can be more prone to disease, increased mortality and can have reduced growth rates.
- The effect of heat stress on labour during summer can be minimised by reducing activities associated with calving, mating and reproduction

With these factors in mind, dairy farmers should carefully review calving patterns with the possibility of adjusting these to avoid exposure to the production costs and losses and negative animal wellbeing implications of milking large numbers of peak producing cows through summer. Any potential change in calving pattern should be accompanied by due consideration of milk markets and business cashflow management. Movement to more seasonal calving patterns needs to carefully consider facilities and labour management implications of consolidating calving and calf rearing activities and appropriate risk management considerations with respect to feed storage and provision during drought and prolonged wet weather.

## **10. Facility design**

Increasingly, farmers are looking to address heat stress management with alternate feeding, housing and management systems. Use of feeding facilities that allow cows to be cooled while feeding with either or a combination of sprinklers, shade and fans, will increasingly become the norm as the production losses and animal well-being implications of not providing these become economically unfeasible and ethically unacceptable to both the industry and the general-public. An increase in the installation of permanent housing structures such as loose or compost barns and modern free stalls appears inevitable. While less acceptable to an under or misinformed public, the choice between having cows either being protected or exposed to both the extremes of heat stress and mud/cold stress should prompt greater industry efforts to influence public perception of what constitutes good animal well-being. Modern, animal and environmentally friendly housing design, if appropriately designed and managed, can provide extremely high-levels of animal comfort under nearly all-weather conditions as well as provide for improved feed conversion efficiency and effluent and environmental management. Detailed discussion of animal housing and feeding options is beyond the scope of this paper but should form part of any modern dairy business's long term strategic planning for climate management.



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# COOL BREEDING: GENOMIC SELECTION FOR HEAT TOLERANCE IN DAIRY CATTLE

**Jennie Pryce**

Thuy T. T. Nguyen<sup>1</sup>, Jennie E. Pryce<sup>1,2</sup>, Josie B. Garner<sup>3</sup>, Phil J. Bowman<sup>1,2</sup>, Mekonnen Haile-Mariam<sup>1</sup> and Ben J. Hayes<sup>1,4</sup>

<sup>1</sup> Agriculture Victoria, AgriBio, Centre for AgriBioscience, Bundoora, Victoria 3083, Australia

<sup>2</sup> School of Applied Systems Biology, La Trobe University, Bundoora, Victoria 3083, Australia

<sup>3</sup> Ellinbank Centre, Agriculture Victoria, 1301 Hazeldean Road, Ellinbank, Victoria 3821, Australia

<sup>4</sup> Queensland Alliance for Agriculture & Food Innovation, University of Queensland, Brisbane, St Lucia, Queensland 4072, Australia

## Introduction

Excessive environmental temperature and humidity can lead to heat stress in dairy cattle. Dairy cows respond to heat stress by reducing feed intake and consequently producing lower milk yield (St-Pierre *et al.*, 2003, West, 1994). Heat stress can also have other serious consequences, such as reduced reproductive performance (Folman *et al.*, 1983, Monty and Wolf, 1974). Mitigating the impacts of heat stress is one of the greatest challenges that the Australian dairy industry will face in the next few decades, due to an increase in the frequency and duration of heat stress events (CSIRO and BoM, 2015).

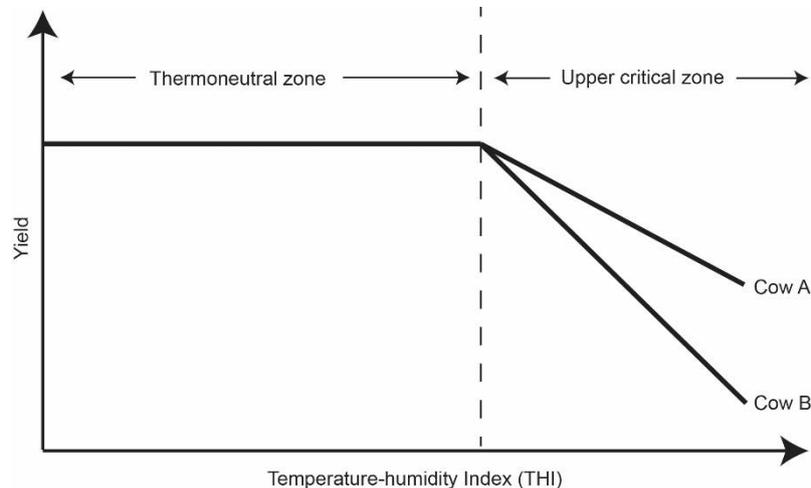
The Cool Cows initiative of Dairy Australia (<http://www.coolcows.com.au>) has been developed to assist farmers by providing forecast of heat events and suggesting management options, including infrastructure improvements and cost-benefit analysis thereof. However, selection for heat tolerant animals is also a promising possibility, as there is genetic variation in animal performance under heat stress conditions (Bohmanova *et al.*, 2008). This enables a long term, permanent and cumulative solution to improve dairy cow heat tolerance. Compared to traditional breeding, genomic selection is well suited to select for heat tolerance as it enables faster rates of genetic gain, as individuals can be selected very early in life. The costs involved in genomic selection will also be minimal as the phenotypes required and genotypes of thousands of cows and bulls are already available in Australia.

Following extensive research into the development of a genomic breeding value for heat tolerance for Australia, the aim of this paper is to describe how breeding values for heat tolerance will be implemented in Australia.

## What is heat tolerance?

Environmental heat load can be influenced by many environmental factors such as temperature, humidity, wind speed and solar radiation. However, since the thermoregulation in cattle is affected largely by air temperature and relative humidity, the temperature-humidity index (THI) which combines temperature and humidity into one value, is the most commonly used index of environmental heat load.

Heat tolerance can be defined as the rate of decline in milk, fat and protein yields per unit increase of THI. Production of heat tolerant cows declines more slowly in response to increasing heat stress when compared to cows that are susceptible. Figure 5 provides an example of how cows perform differently under heat stress conditions. Under the thermoneutral condition, that is within the comfortable zone, both cow A and cow B produce a similar amount of milk, for example. When THI increases beyond the thermoneutral zone (the upper critical zone), that is heat stress conditions, cow B produces less milk than cow A. This indicates that cow A is more tolerant to heat stress than cow B.



**Figure 5. An illustration of how cows perform differently under heat stress conditions (adapted from Bloemhof *et al.* (2008)).**

### The technical foundation

There were four phases to the development of heat tolerance genomic breeding values (GEBV): 1) Development, 2) Validation, 3) Improvement of reliability, and 4) an implementation plan to select for heat tolerance.

### Development of heat tolerance genomic breeding value

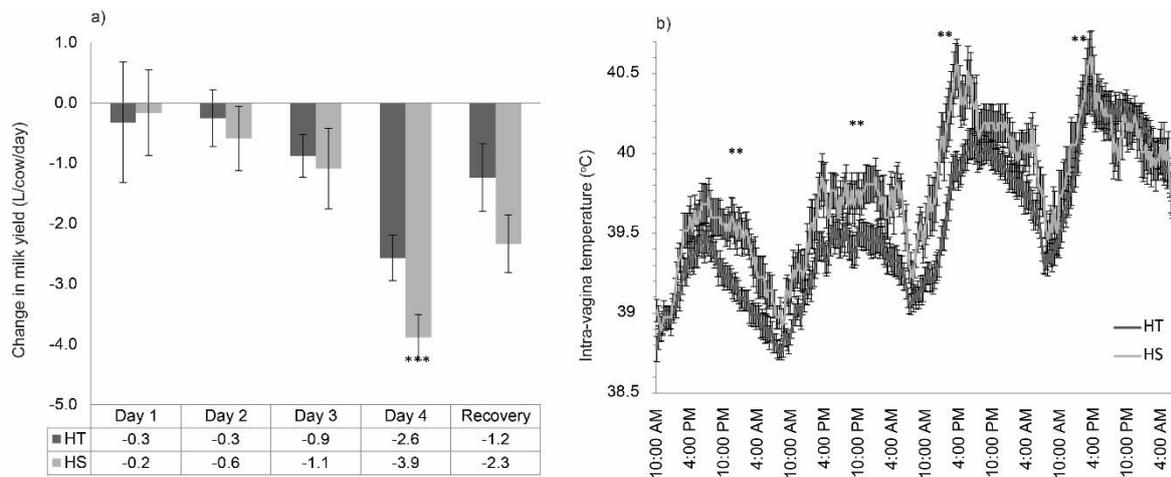
In an initial analysis, Nguyen *et al.* (2016a) developed genomic breeding values (GEBV) for heat tolerance using herd test records from 1,762 Holstein and 519 Jersey dairy herds. Herd test records from 366,835 Holsteins and 76,852 Jersey cows were combined with daily temperature and humidity measurements from weather stations closest to the tested herds, for test days between 2003 and 2013. Daily mean values of THI averaged for the day of test and the four previous days (THI) was used as the measure of heat stress. Tolerance to heat stress was estimated for each cow using a random regression model, and the slope solutions for cows from this model were used to define the phenotypes of 2,735 Holstein and 710 Jersey sires, which were genotyped for 800K SNP. Genomic best linear unbiased prediction (GBLUP) was used to calculate GEBV for heat tolerance, for milk, fat and protein yield. Heat tolerance GEBV was found to be unfavourably correlated to ABV of production traits, and favourable to fertility.

### Validation of heat tolerance genomic breeding value

Heat tolerance GEBV was validated using two approaches, including cross validation and empirical validation.

- Cross validation: Using 435 Holstein and 135 Jersey sires as validation populations, Nguyen *et al.* (2016a) reported accuracies of heat tolerance on milk, fat and protein from 0.43 to 0.51 and 0.49 to 0.52 in Holsteins and Jerseys, respectively. The corresponding expected reliabilities were 0.19 – 0.26 and 0.24 – 0.27, respectively.

- Empirical validation: In a study conducted by Garner *et al.* (2016), 390 first lactation Holstein heifers were genotyped and GEBVs for heat tolerance were predicted using the equation developed by Nguyen *et al.* (2016a). The 24 animals with the highest predicted GEBV for most heat tolerance and the 24 animals predicted to be most heat susceptible were selected for the trial. The 48 cows were randomly assigned to controlled-climate chambers for a 4 day heat challenge. Daily temperatures and relative humidity inside the chambers were cycled to approximate diurnal patterns and ranged from 23.3 to 31.6°C (26.3°C mean) and from 42.2 to 71.2% relative humidity (55.2% mean) (THI = 71.6 to 82.1, 75.4 mean). The predicted heat tolerant group had significantly less decline in milk production ( $P < 0.05$  Figure 2a), and lower core temperature (Figure 2b) during the simulated 4 day heat wave event, than the predicted heat susceptible group. The results indicate that heat tolerance GEBV can be reliably used to distinguish heat tolerant and heat susceptible animals.



**Figure 6. a) Changes from the baseline in mean daily milk yield for the predicted heat tolerant and heat susceptible cows; b) Intra-vaginal temperature for the predicted heat tolerant (HT) and heat susceptible (HS) cows over the four day heat challenge.**

In order to increase the rate of genetic gain, it is important to improve the reliability of genomic prediction. One option is to expand the reference populations by adding more genotyped cows. We used the genotyped cows from the Genomic Information Nucleus Herds (Ginfo) for this purpose. In order to implement heat tolerance breeding value under the DataGene evaluation system, we estimated the effects of the SNP in the lower density SNP (50K) instead of those in high density SNP data (800K).

We re-estimated heat tolerance GEBV following the methods of Nguyen *et al.* (2016a) with several changes: 1) the herd-test records and climate data used by Nguyen *et al.* (2016a) were extended to Aug 2016; 2) the distance between herds and weather stations were measured using the GPS coordinates of each herd instead of its postcode centroid, where possible; 3) the sizes of reference populations for Holsteins and Jerseys were expanded to 11,853 cows and 2,236 sires, and 4,268 cows and 506 sires, respectively; and 4) we used genotypes of 46,726 SNPs which are currently used by the DataGene for genomic evaluation.

The realised reliabilities were calculated for three different analyses: 1) using sires only in the reference (2,236 Holsteins and 506 Jerseys); 2) using sires + non-Ginfo cows (4,711 Holsteins and 3,153 Jerseys) in the reference; and 3) using sires + non-Ginfo cows + Ginfo cows in the reference (7,142 Holsteins and 1,115 Jerseys). The validation populations for Holsteins and Jerseys were 504 and 161 sires, respectively. **Table 1** shows the mean realised reliabilities of heat tolerance GEBV using 46,726 SNP panel under three scenarios. When non-Ginfo cows and sires were used as the reference population, reliabilities of heat tolerance GEBV were increased by 1 – 2 % in Holsteins and 1 – 3 % in

Jerseys. When Ginfo cows were added to the reference, reliabilities of heat tolerance GEBV were further increased by 3 – 6 % in Holsteins and 6 – 7 % in Jerseys. Results from this study are encouraging, suggesting that reliabilities of genomic evaluation for heat tolerance should improve as more and more cows are added to the reference population.

**Table 1. Mean reliabilities of heat tolerance GEBV predicted using 46,726 SNP panel with three different reference populations (sires only, sires + non-Ginfo cows, sires + non-Ginfo + Ginfo cows)**

| Breed    | Traits affected by heat stress | Sires only | Sires + non-Ginfo cows | Sires + non-Ginfo + Ginfo cows |
|----------|--------------------------------|------------|------------------------|--------------------------------|
| Holstein | Fat                            | 0.36       | 0.38                   | 0.44                           |
|          | Milk                           | 0.37       | 0.39                   | 0.42                           |
|          | Protein                        | 0.36       | 0.37                   | 0.40                           |
| Jersey   | Fat                            | 0.27       | 0.28                   | 0.35                           |
|          | Milk                           | 0.30       | 0.32                   | 0.39                           |
|          | Protein                        | 0.29       | 0.32                   | 0.38                           |

### Plan for implementation

*Expression of heat tolerance.* Heat tolerance can be expressed in many ways (Nguyen *et al.*, 2016b). Following the consultation with industry, heat tolerance will be expressed as the decline in the Australian Selection Index (ASI; which includes milk, fat and protein yields weighted by their respective economic weights) per unit increase in the temperature-humidity index (THI), on the scale of 100 mean and 5 units = 1 standard deviation (i.e. as for type traits). So, a bull with a breeding value greater than 100 means his daughter are more heat tolerant than average. A bull with an ABVg less than 100 means his daughters are less heat tolerant than average.

*Calculation of HT ABVg.* The HT ABVg is a direct genomic breeding value (DGV). That is a genomic only breeding value. The HT ABVg were calculated separately for Holsteins and Jerseys, as follows:

- Calculate DGV for decline in milk ( $DGV_{HT\_milk}$ ), fat ( $DGV_{HT\_fat}$ ) and protein ( $DGV_{HT\_prot}$ ) yields with heat stress for genotyped animals using the SNP effects resulting from back solving the solutions of the GBLUP model.
- Calculate DGV for decline in ASI with heat stress as:

$$DGV_{HT\_ASI} = EW_m * DGV_{HT\_milk} + EW_{fat} * DGV_{HT\_fat} + EW_{prot} * DGV_{HT\_prot}$$

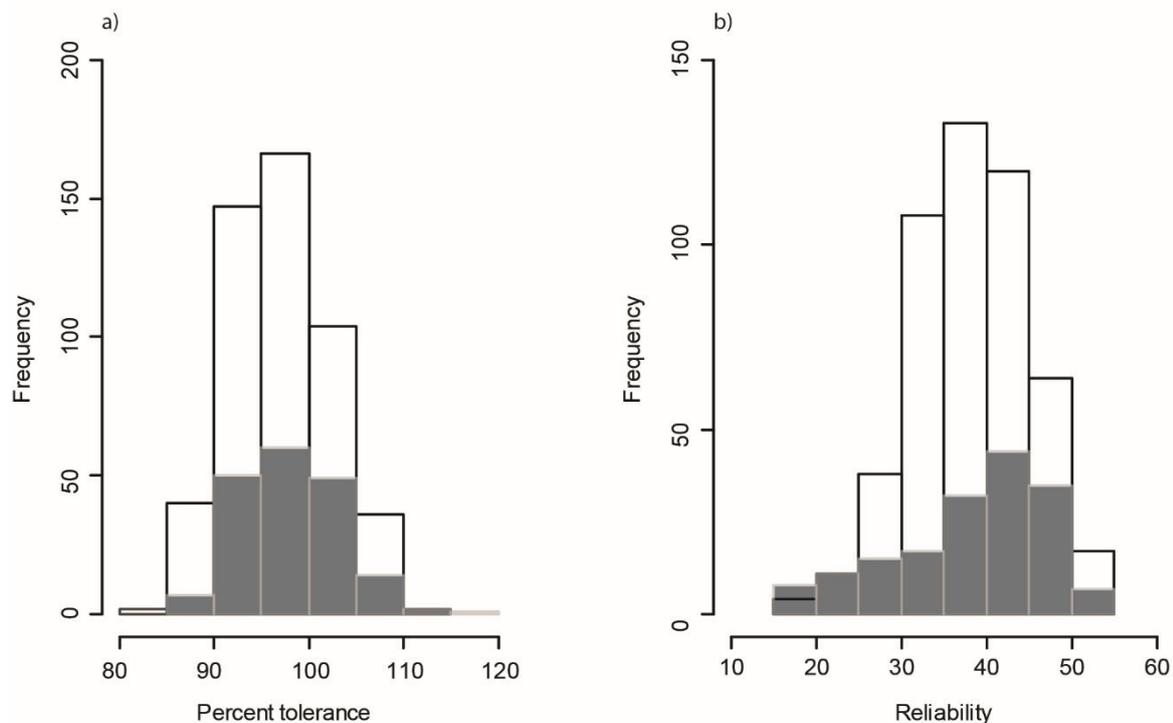
where  $DGV_{HT\_ASI}$  is the decline of ASI per unit increase in THI,  $EW_m = -0.10$ ,  $EW_f = 1.79$ ,  $EW_p = 6.92$ , are the economic weights of milk, fat and protein respectively, which are currently used in ASI (Byrne *et al.*, 2016).

- Express heat tolerance in percentage (mean= 100, standard deviation = 5)

$$HT\ ABV_g = 100 + 5 * [DGV_{HT\_ASI} - \text{mean}(DGV_{HT\_ASI})] / \text{sd}(DGV_{HT\_ASI})$$

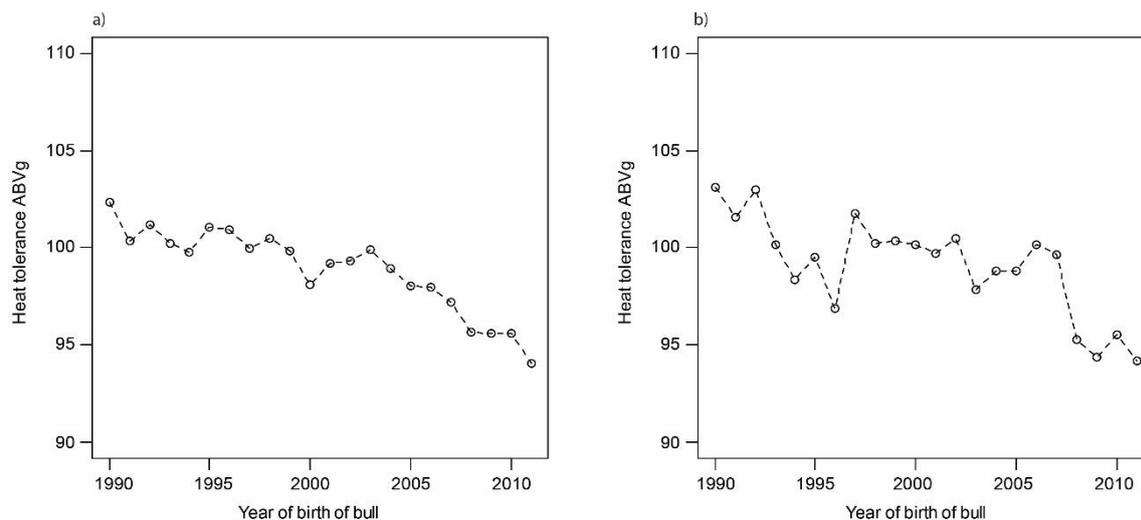
Expression in percentage has the advantage that it is free of THI units and effectively becomes a ranking.

Figure 7 shows the distributions of a) HT ABVg for Holstein and Jersey bulls. HT ABVg ranged from 84% to 112% (-4SD to +3SD) in Holsteins and 86% to 117% (-3SD to +4SD) in Jerseys(b) and b)The reliability of HT ABVg in genotyped Holstein bulls with no daughters in the reference set ranged from 16% to 54%, had a mean of 38% and a standard deviation of 7%. In Jerseys, the reliability of HT ABVg ranged from 15% to 54%, had a mean of 38% and a standard deviation of 9%.



**Figure 7. Distributions of a) Australian genomic breeding values for heat tolerance in 497 Holstein (white bars) and 183 Jersey bulls (grey bars) without daughters in the reference; and b) corresponding reliability.**

Genetic trends for both Holsteins and Jerseys show a slight decline in heat tolerance over time (Figure 8). This is expected given the unfavourable correlation of heat tolerance with milk production (Nguyen *et al.*, 2016a). Between 1990 and 2011, HT ABVg declines at the rate of 0.3% per year in both Holsteins and Jerseys. This indicates that herds in a warmer climate should take steps to prevent a further decline in heat tolerance. The best way to achieve this is to have heat tolerance included in the current selection indices such as BPI so that heat tolerance can be selected jointly with other economic drives (see below).



**Figure 8. Genetic trend of ABVg for heat tolerance in a) 2,665 Holstein and b) 641 Jersey bulls born in and after 1990.**

*Future scenarios selection tool.* Given the unfavourable correlation between heat tolerance and production traits, one relevant question is how farmers can balance the selection for heat tolerance with other existing priorities. In this regard, Nguyen *et al.* (2016b) developed a web-based application (<https://tnshinyr.shinyapps.io/app12/>) which can be used to visualise the specific level of THI for each postcode, the Balanced Performance Index (BPI) of cows and bulls under each specific heat load, and the values and ranking of the “augmented” index, which incorporated HT ABVg into BPI.

## Next steps

As part of the DairyBio program, we will investigate the impacts of heat stress on health and fertility traits and investigate intermediate predictors of heat tolerance. We will also take steps to derive conventional breeding values for heat tolerance.

## Conclusions

We have described the research platform leading to the implementation of a new breeding value for Holstein and Jersey cattle in Australia – the heat tolerance breeding value. This is a genomic only breeding value, which was derived from a very large dataset by merging the herd test production records with weather data, and a large population of genotyped cows and bulls. The breeding value was validated by using both cross and empirical validations. Although the mean reliability of this new trait is moderate, it is expected that this will improve as the reference populations are extended. To facilitate the use and selection on HT information by farmers we have developed a selection tool that optimally combines the current economic indexes such as BPI and heat tolerance. In May 2017 the first provisional breeding values for heat tolerance were released by DataGene to the Australian dairy industry, we expect official breeding values to be released later in 2017.

## Acknowledgements

The studies on development and validation of heat tolerance GEBV, and the development of future scenarios selection tool were funded by the Australian Department of Agriculture and Water Resources. The work on improvement of reliabilities of heat tolerance genomic breeding values were funded by the DairyBio program, which is co-funded by the Department of Economic Development, Jobs, Transports and Resources, and Dairy Australia. The authors would like to thank DataGene for providing production and genotype data.

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## 2017 EMERGING SCIENTISTS PROGRAM

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### Alexandra Green

Alexandra Green is a second year PhD student within the Dairy Science Group at the University of Sydney. Her background is in Animal and Veterinary Bioscience and she completed her degree with first class honours in 2015.



Alexandra has a keen fascination for animal behaviour, having worked with a variety of species including dogs, wildlife and cattle. She is especially interested in how animal behaviour can be interpreted in production systems to assess the welfare and productivity of animals.

For her PhD she is focusing on dairy cattle vocal behaviour and her research involves analysing the vocalisations of dairy heifers in response to different farming contexts, such as feeding, social isolation, oestrus and calf separation. Her ultimate goal is to determine what cattle vocalisations mean and to apply this knowledge to help farmers better manage their livestock. Upon completion, Alexandra hopes to continue working in this behavioural field and travel the world in the process.

### Beth Scott

From a four-year-old feeding calves to a 13-year-old starting her own jersey stud on her parents' Gippsland farm, Beth has always loved being in the dairy industry. During her Bachelor in Animal and Veterinary Bioscience Beth completed a professional experience program where she spent five days at DataGene (formally ADHIS).

It was this insight into dairy genetics that drove Beth to learn more about the Breeding and Genetics field. Beth completed her Bachelor in 2014 and returned home to work on the family farm. This turned out to be short lived where in mid-2015; Beth was accepted into Masters of Animal Science at Wageningen University, the Netherlands. The move had an added bonus where she was able to combine two of her favourite things – cows and hockey.



The two year course allowed her to specialise in Animal Breeding and Genetics where she has undertaken 12 months of coursework and is in the final months of the 12 month research component. The Dutch exchange student is currently based at the Department of Economic Development, Jobs, Transport and Resources in Victoria.

Beth hopes her Jersey Australia funded research into the genetics of stillborn Jerseys and Holsteins will be able to assist farmers to make better breeding decisions to improve calving performance. Not only is this research something she is passionate about but is close to her heart as she knows first-hand the impact of stillbirth on her small Jersey herd.

## Jo Newton

Jo Newton works as a Research Scientist in Dairy Genetics for Agriculture Victoria. She currently works on *ImProving Herds*, a national project initiated by the Gardiner Foundation that aims to equip dairy farmers with the tools and knowledge to make quick, clever decisions to increase herd performance and farm profitability.



Prior to this, Jo spent 8 years based in Armidale, NSW. In 2015 Jo completed a PhD in Animal Genetics and Breeding at the University of New England (UNE). Her thesis explored the genetic and environmental factors influencing sexual maturity and reproduction in young ewes and the implications this has in designing breeding programs. Jo also completed a Bachelor of Rural Science (Hons) at UNE graduating with first class honours and a University Medal.

Whilst studying, Jo worked on several farms in NSW and as a casual academic at UNE. A highlight of this time was designing and implementing a breeding program that included the use of breeding values for Stanley Vale Merinos, a Merino stud in Uralla, NSW. This very “hands-on” experience in using genetic tools on-farm coupled with Jo’s fieldwork experience during her thesis fostered a keen interest in how agricultural industries can benefit from advances in livestock genetics and genomics.

As a city girl who fell in love with agriculture Jo has become an advocate for agriculture’s diverse and rewarding career pathways and enjoys talking to school and uni students about her pathway into agriculture.

## Alex John

Alex John is a 3<sup>rd</sup> year PhD student from the University of Sydney, studying ways to improve robot utilisation in pasture-based automatic milking systems.



He formerly completed his Bachelor of Agricultural Science at the University of Tasmania, where he gained an interest for emerging agricultural technologies whilst completing an honours thesis, also related to robot milking.

With the fast rate of development in both robotics and computing, Alex is excited to see what the future holds for agriculture, and in the future, hopes to continue working to help mesh together precision technologies and agricultural production systems.

## Juan Molfino

Juan Molfino was raised spending every opportunity he could get on his grandfather's dairy farm back in Argentina. Later on he started working on his family beef and crop farm whilst completing his Bachelor degree in Agriculture. After finishing his degree he moved to New Zealand where he worked on a commercial Dairy farm, before making the move across the ditch to Australia.



Juan joined FutureDairy in 2012 to work on Camden Automatic Milking System research farm and later he conducted the Labour & Lifestyle audits on commercial farms operating with AMS with the objective of evaluate the impact of this technology in Australian farms. In 2014 Juan commenced a PhD in Veterinary Science focusing on how to increase efficiencies in pasture-based Automatic Milking Systems.

Juan's primary interest is in how to make pasture-based dairy systems more sustainable, profitable, and competitive; and how to best integrate robotic milking systems into Australian dairy.

## Veronica Vicic

My name is Veronika Vicic and I'm currently in my 4th year of animal science at Charles Sturt University in Wagga Wagga. This year I am undertaking an honours project researching the eating quality of Holstein beef. I decided to study this degree because I wanted to become more aware of the food supply chain.



Growing up and living in Sydney for majority of my life did not expose me to the Australian Agriculture industry. I wanted to become a part of an industry that had high value in society and possibly one day become a primary producer.

Now that I am in my final year of university I want to be able to use the knowledge and skills I gained from this degree to be innovative, help the industry maintain high standards and keep up with the continual shift in market products that consumers are demanding.

I am also very passionate about bridging the urban-rural divide and connect individuals in cities to the farm gate.

## Ashleigh Wildridge

Ashleigh Wildridge is a PhD candidate coming towards the end of her studies with the University of Sydney at Camden. Prior to her PhD, Ashleigh completed her undergraduate degree in Animal Science with Charles Sturt University at Wagga Wagga.



Her PhD explores automatic milking systems (AMS) and the ways in which farmers, cows and certain infrastructure interact within the system.

With a strong focus on behaviour and welfare, Ashleigh has explored a common problem in an unfamiliar setting, providing the first research on heat stress in a pasture based AMS. Following on from this, she has also explored the changes to the human-animal relationship on five conventional dairy farms transitioning to AMS.

Ashleigh's research has driven her interest in working with farmers, with hopes of continuing to do so after the completion of her PhD. Ashleigh's other passions include horse riding, four-wheel driving and camping/travelling in the amazing Australian bush.

## Laura Senge

Originally from Germany, Laura came to Australia 3 years ago to enjoy a bit of sun whilst studying Environmental Engineering at Murdoch University in Perth.

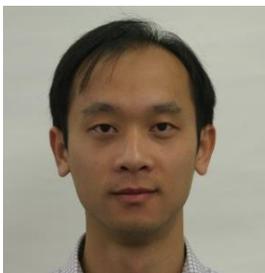


After a couple of years of casual bar work, she discovered that she had a passion for water treatment and started her first job on Rottnest Island working on a waste water treatment plant.

Even though she does not have a history within the dairy industry, this led to her current honours project being conducted in the dairy production, looking at waste water generated on the farm, targeting zero nutrient discharge.

## Paul (Long) Cheng

Dr Paul (Long) Cheng graduated from Lincoln University, New Zealand in 2008, with a Bachelor of Agricultural Science with Honours. In 2009 Dr Cheng commenced his PhD, investigating the use of nitrogen isotopic fractionation as a biomarker to indicate nitrogen use efficiency of ruminants, graduating in 2013 from Lincoln University, New Zealand.



Dr Cheng then took up a part time lecturer position to teach livestock production system course, before commencing a postdoc position with The Agricultural and Marketing Research and Development Trust (AGMARDT), New Zealand to investigate the use of herbs for dairy heifer production. Dr Cheng conducted 25 ruminant research projects in Australia and New Zealand and also collaborated with 12 institutions from seven countries over the past five years.

Dr Cheng published more than 40 refereed paper, covering studies ranging from monogastric to ruminant, from nutrition to genetics, from animal production to product quality. As a Lecturer in Livestock Nutrition and Grazing Management and subject coordinator of Systems Biology and Animal Systems at The University of Melbourne, Dr Cheng is committed to deliver high quality teaching and research programs to students.

# THE VOCALISATIONS OF HOLSTEIN-FRIESIAN DAIRY HEIFERS IN RESPONSE TO SOCIAL ISOLATION AND FEEDING

**A.C. Green<sup>AC</sup>, I. Johnston<sup>A</sup>, S. Lomax<sup>A</sup>, D. Reby<sup>B</sup>, E.F. Briefer<sup>D</sup>, C.E.F. Clark<sup>A</sup>**

<sup>A</sup> School of Life and Environmental Sciences, Faculty of Science, The University of Sydney, Camden, NSW, 2570, Australia

<sup>B</sup> School of Psychology, University of Sussex, Brighton, BN1 9QH, United Kingdom

<sup>D</sup> ETH Zürich, Institute of Agricultural Sciences, Universitätstrasse 2, 8092 Zürich, Switzerland

<sup>C</sup>Corresponding author. Email: a.green@sydney.edu.au

## Abstract

Dairy cattle vocalisations contain information about their physical attributes alongside their emotional and physiological state. The ability to use these vocalisations on dairy farms to improve cattle welfare, management and feed-conversion efficiency remains largely unexplored. The purpose of this study was to characterise the vocalisations of dairy cattle in different emotional contexts. Vocalisations were recorded over 8 weeks at 'Wolverton' farm on 20 Holstein-Friesian heifers aged 23 – 24 months. Vocalisations were produced in response to 30 minutes of social isolation, either partial or full, anticipation of daily feeding and feed frustration, where some heifers were unable to access food whilst their conspecifics were eating. During the observations, two different call types were apparent, namely open and closed-mouth calls which significantly differed in F0 parameters ( $P \leq 0.003$ ).

In comparing the open-mouth calls across the contexts, all the F0 parameters significantly differed, with partial isolation having the lowest mean F0, maximum F0 and F0 range of all the contexts ( $P < 0.05$ ). Further, feed frustration had a significantly higher minimum F0 value compared to other contexts ( $P < 0.05$ ). These results improve our knowledge of cattle vocal communication and suggest that with further analysis, acoustic monitoring could help decipher cattle requirements and improve on-farm management.

## Introduction

With dairy herd sizes increasing, attention has been directed towards behavioural monitoring technologies to assist farmers in managing their animals at the individual level. A field of interest is bioacoustics, or the study of cattle vocal behaviour, which could provide a non-invasive method of assessing how cattle are coping in response to different farming contexts.

While little is known about the information encoded in cattle vocalisations, in goats, pigs and horses, indicators of emotion have been mapped out in their calls (Briefer *et al.*, 2015; Briefer *et al.*, 2015; Linhart *et al.*, 2015). Emotions lead to changes in the autonomic

nervous system such as changes in respiration and salivation as well as tension in the muscles used for vocal production (Briefer, 2012). As a direct consequence of these physiological processes, there are changes in vocal parameters. If an animal is highly aroused, the fundamental frequency (F0), F0 range, amplitude and calling rate will all increase (Briefer, 2012; Linhart *et al.*, 2015). Our objective was to characterise the vocalisations of dairy heifers in response to negative contexts likely differing in arousal, namely partial or full isolation, and feed-frustration, alongside the positive context of feed-anticipation. It was hypothesised that there would be context-related vocal variation linked to underlying emotions.

## Materials and Methods

### **Animals and management**

All experiments were conducted with ethics approval (project number 2016/1078) and were undertaken at the University of Sydney, Camden campus 'Wolverton' farm over 8 weeks during the autumn of 2017. 20 Holstein-Friesian heifers were selected to have a similar age ( $23.5 \pm 1$  months) and weight ( $441.5 \pm 37.5$  kg) at the beginning of the experiments. Further, they were intramuscularly administered 2ml of PGF2 $\alpha$  so that their oestrus cycle was synchronised. Vocal recordings commenced after the 96 hours of oestrus to ensure that vocalisations were associated with the contexts provided rather than oestrus activity. Outside of testing hours, the heifers were housed together in a paddock where they were offered lucerne hay to maintenance (10kg/day) and had ad-libitum access to water.

### **Experimental procedure**

Our 2 experiments were conducted in a circular cattle yard (27m<sup>2</sup>) and paddock (8,000m<sup>2</sup>). Vocal responses of heifers were recorded when socially isolated (1) and when feed was provided (2). Heifers were habituated to the yards over 2 days before the experiment so that vocalisations were in response to the treatment rather than novel surroundings.

Experiment 1): Isolation. 12 out of the 20 heifers were isolated, including 8 partially isolated and 4 fully isolated. A circular cattle yard, was used for both isolation treatments (partial and full) and was altered to fit the requirements of each treatment. For partial isolation, the isolated heifer had visual, olfactory and auditory contact with her conspecifics that were situated in the paddock, between 2 m and 95 m away.

For full isolation, the fencing surrounding the isolation yard was covered in black tarpaulin to prevent visual and olfactory contact with conspecifics. However, the isolated heifer and her conspecifics were still able to maintain auditory contact. Each heifer was subject to 30 minutes of isolation per day, for no more than 4 days. The heifers and treatments were both applied in a random order.

Experiment 2): Feeding. 20 heifers were trained via classical conditioning over 7 days to associate a herdsman and the word 'food' in the paddock with the act of obtaining their daily feed allowance. Over the 7 days, there was a growth in the conditioned response (vocalisations in anticipation of feed) and vocal responses were recorded for the 10 minutes prior to feed provision on each day.

To induce vocalisations associated with feed-frustration, classical conditioning methods were also applied, this time in the yards. Instead of all 20 heifers accessing their feed concurrently, only 4-6 heifers were let through to the circular yard where they were offered 2kg of lucerne hay. Their conspecifics observed in frustration over their inability to access this reward. Feed frustration vocalisations were recorded over 2 separate days and following each frustration recording, heifers were offered their daily feed allowance in the paddock.

### **Vocal recordings and acoustic analysis**

Call type was classified as open-mouth or closed-mouth based on visual observations at the time of the recording. Calls were captured using a Sennheiser ME67 directional microphone (frequency response 40 – 20000 Hz; max SPL 125 dB at 1kHz) with the microphone at a distance of 2 to 10 metres from the vocalising heifers. This microphone was attached to a Marantz PMD661 MK2 digital solid state recorder with stereo input (sampling rate: 44.1 kHz). Each vocalisation was stored as a separate file in the .WAV uncompressed format at 16-bit amplitude resolution.

Calls were visualised as narrow band spectrograms and only calls with a high signal to noise ratio, and those from different calling bouts were considered for spectrographic analysis. We then characterised the duration and the fundamental frequency (F0) of the calls using a custom built script (Briefer *et al.*, 2015; Reby and McComb, 2003) in Praat v.6.0.17.

### **Statistical Analysis**

Sample sizes for the acoustic analysis differed between each context with 4-10 calls included for each vocalising individual. Statistical analyses were conducted using Genstat, version 18. All parameters were log transformed due to non-normality. To compare

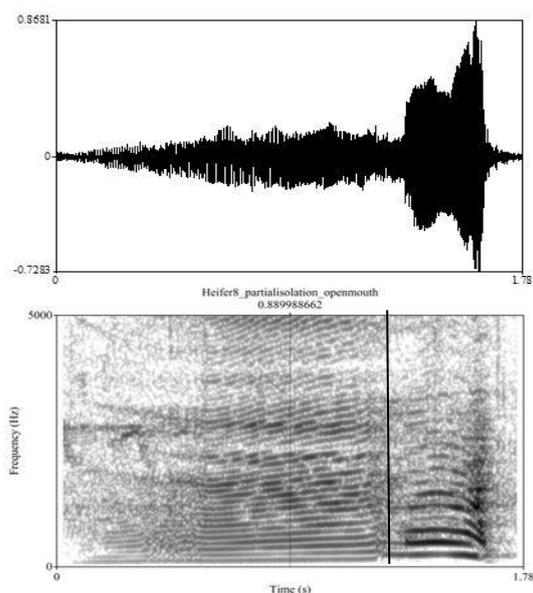
the acoustic features of the open and closed-mouth calls, a generalised linear mixed model was run, with each vocal parameter as the response, mouth position as the fixed effect and heifer as the random effect.

To determine the effect of context on each call parameter, only the open-mouth calls were examined. A generalised linear mixed model was also run, with each vocal parameter as the response, context as the fixed effect and heifer as the random effect. Differences in mean values for the significant acoustic parameters were further assessed using least significant difference tests.

## Results

### Call type

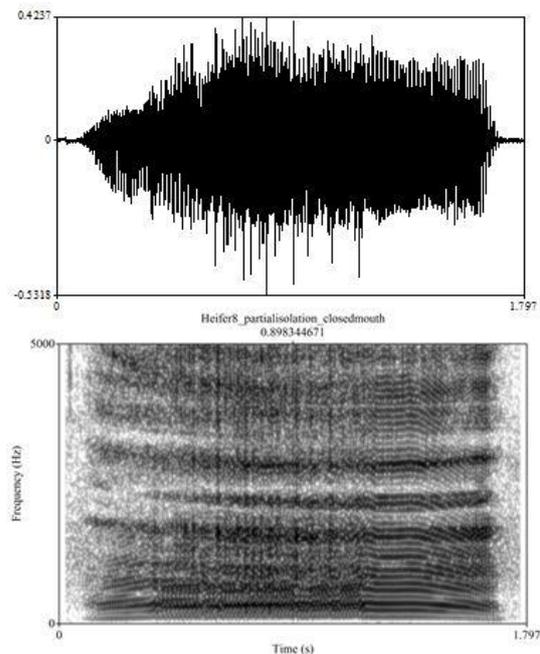
A total of 131 open-mouth and 35 closed-mouth vocalisations were included in the analysis (Figures 1 to 3). Open-mouth calls differed from closed-mouth calls in almost all of the investigated acoustic parameters including mean F0, minimum and maximum F0, and F0 range ( $P \leq 0.003$ ). Open-mouth calls were characterised by a mean F0 of  $216.7 \pm 80.2$  Hz and a mean duration of  $1.9 \pm 0.6$  s. In contrast, closed-mouth calls had a mean F0 of  $82.7 \pm 10$  Hz and a mean duration of  $1.81 \pm 0.8$  s.



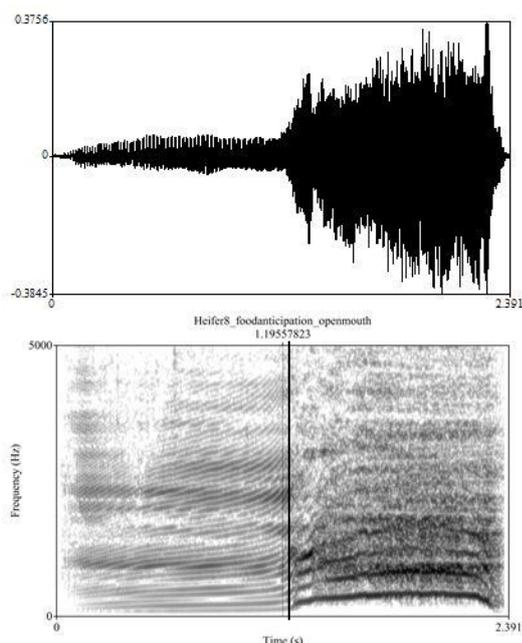
**Figure 1. Waveform (top) and spectrogram (bottom) of a closed-mouth call produced by Heifer 8 during the negative context of partial isolation.**

### Calls of each context

Across the contexts, the mean F0, minimum and maximum F0 and F0 range significantly differed ( $P \leq 0.003$ ). Calls produced during partial isolation had a significantly lower F0, maximum F0 and F0 range than calls in other behavioural contexts ( $P < 0.05$ ; Table 1). Calls produced during feed frustration had a significantly higher minimum F0 than calls produced during partial isolation and feed anticipation ( $P < 0.05$ ).



**Figure 2. Waveform (top) and spectrogram (bottom) of an open-mouth call produced by Heifer 8 during the negative context of partial isolation. The first part of the call (left of line) is initially closed-mouth and the second part of the call (right of line) is open-mouth, coinciding with an increase in F0 and amplitude.**



**Figure 3. Waveform (top) and spectrogram (bottom) of an open-mouth call produced by Heifer 8 during the positive context of feed anticipation. The first part of the call (left of line) is initially closed-mouth and the second part of the call (right of line) is open-mouth, coinciding with an increase in F0 and amplitude.**

**Table 1. Average values of acoustic parameters within each context. <sup>A,B</sup> Significantly different (P<0.05)**

| Context           | F0 (Hz)            | Min F0 (Hz)       | Max F0 (Hz)        | F0 range (Hz)      | Sound duration (s) |
|-------------------|--------------------|-------------------|--------------------|--------------------|--------------------|
| Partial isolation | 140.4 <sup>A</sup> | 70.3 <sup>B</sup> | 206.5 <sup>A</sup> | 136.3 <sup>A</sup> | 1.6                |
| Full isolation    | 252.9 <sup>B</sup> | 77.5              | 428.3 <sup>B</sup> | 350.8 <sup>B</sup> | 1.8                |
| Feed anticipation | 220.0 <sup>B</sup> | 74.2 <sup>B</sup> | 359.1 <sup>B</sup> | 284.9 <sup>B</sup> | 2.0                |
| Feed frustration  | 237.7 <sup>B</sup> | 90.9 <sup>A</sup> | 353.0 <sup>B</sup> | 262.2 <sup>B</sup> | 1.7                |

## Discussion

The open and closed-mouth calls of dairy cattle appear to differ in acoustic structure, in accordance with beef cattle (Padilla de la Torre *et al.*, 2015). Spectrographically, there were also some differences between the calls of the selected contexts. Partial isolation

appears less arousing than the other contexts, indicated by the lower F0-related parameters. This is in alignment with the study of Johnsen *et al.* (2015), where partial isolation was described as less stressful than full isolation in the context of cow and calf.

From an applied perspective, this may suggest that on farm when cattle are separated for management procedures, visual and auditory contact with their herd should be maintained. To confirm this preliminary finding, future studies should involve a greater number of test subjects to account for any individual variability and the low incidence of calls produced by some cattle.

For the feeding contexts, the minimum F0 value during feed-frustration was significantly higher than during feed-anticipation, suggesting that there are positive and negative context specific acoustic features. However, as this value did not differ from full isolation, additional acoustic parameters should be explored to determine which acoustic parameters can be analysed to monitor emotional valence and welfare.

Future studies should adopt a dimensional approach to classify emotions, similar to what has been completed in goats (Briefer *et al.*, 2015), which involves classifying contexts according to both the emotional arousal (high or low) and valence (positive or negative) that they trigger. To confirm any vocal correlates of emotion, physiological parameters and other behaviours should also be observed.

## Conclusion

Our experiments highlight the opportunity to use acoustic monitoring to improve cattle management, welfare and feeding, but should be subject to further research including a more detailed acoustic analysis. Extension of this study should also involve testing the same cattle across all the contexts to determine vocal differences on an individual animal basis.

## Acknowledgements

I am very grateful to Kim McKean, Neville Catt, and Paul Lipscombe, along with all the other farm staff and students who assisted me with the study.

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# FACTORS AFFECTING STILLBIRTHS IN AUSTRALIAN JERSEYS AND HOLSTEINS

Scott, B.<sup>ABD</sup>, Pryce, J.E.<sup>BC</sup>, Abdelsayed, M.<sup>B</sup> and Haile-Mariam, M.<sup>B</sup>

<sup>A</sup>Wageningen University, Wageningen, Gelderland 6708 PB, The Netherlands

<sup>B</sup>Agriculture Victoria, Agribio, Centre for AgriBiosciences, Bundoora, VIC 3083, Australia

<sup>C</sup>School of Applied Systems Biology, La Trobe University, Bundoora, VIC 3083, Australia

<sup>D</sup>Corresponding author. Email: beth.scott@wur.nl

## Abstract

Calving performance traits such as stillbirth, calving difficulty and gestation length are important functional traits which affect herd profitability and animal welfare. In Australia, studies to quantify the level of stillbirth and factors that affect it have been limited by the quantity and quality of the data. The study objectives included evaluating the rates and factors affecting stillbirth in Australian Jerseys and Holsteins using calving performance data provided by DataGene. Linear models were used to analyse data on stillbirth for Jerseys and Holsteins separately.

Over the past 20 years the incidence of stillborn births has increased from 2.5% in 1995 to 13.8% in 2015, while in Holsteins it has increased from 4% to 8.5%. In both breeds, stillbirth rates were higher in heifers and animals that experienced dystocia. Over the same period inbreeding levels have increased in both breeds and are currently higher in Jerseys than Holsteins. Inbreeding had a negative effect on calf survival in Holstein heifers although it did not have a significant effect in Jerseys. Preliminary analyses using Australian data suggest that there is an opportunity to use genetic selection to reduce the incidence of stillbirth, and to improve other calving performance traits.

## Introduction

Stillbirth can be defined as death of the perinate prior to, during or within 48 hours of calving, following a gestation period of at least 260 days, irrespective of the cause of death or the circumstances related to calving (Mee, 2008). Stillbirth (SB) is highest in first calving animals and there is variation between breeds (Yao *et al.*, 2014). In Holsteins, SB is known to be associated with calving difficulty (CD), a significant economical and biological stress, whilst in Jerseys most calving's are unassisted. Previous Australian studies have explored the importance of CD and gestation length on calving performance (McClintock, 2004), however, few studies have investigated the effect of inbreeding on calf survival.

Stillbirths or in-utero deaths can occur due to the inheritance of 2 copies of a lethal allele (homozygous) at a given locus, in most cases this has occurred because of a mutation arising in comparatively recent common ancestor. Having a common ancestor is also the reason why inbreeding occurs.

The more recent the ancestor, the more likely homozygous alleles that are identical by descent will have occurred. In dairy cattle, intense selection pressure for traits of economic importance has resulted in a comparatively small effective population size which are estimated to be around 55 for Jerseys and 115 for Holsteins using rates of inbreeding (Stachowicz *et al.*, 2011). Inbreeding depression is associated with a reduction in cow fitness and performance (Pryce *et al.*,

2014). One study found inbreeding coefficients consistently higher in stillborn Holstein calves ( $P > 0.05$ ; Hinrichs and Thaller, 2011). The effects of inbreeding on calf survival in Jerseys are yet to be quantified.

The aim of this study is to quantify the rates of SB and inbreeding and determine the most important factors that affect SB using data from Australian Jerseys and Holsteins collected over several years.

## Materials and Methods

### Data

The data for the study was provided by DataGene from farms that submit calving performance records to herd test centers with a corresponding pedigree file.

A stillborn calf is defined as death of the perinate prior to, during or within 48 hours of calving, following a gestation period of at least 260 days, irrespective of the cause of death or the circumstances related to calving. Due to our data structure SB in this study was defined as a calf that was reported dead by the farmer. SB was coded as 0 for a stillborn calf and 1 for a live born calf. Calving difficulty, CD, was scored on a scale of 1 to 4; where 1 = no assistance, 2 = slight assistance, 3 = moderate assistance, and 4 = extreme difficulty. Calf size was scored on a scale of 1 to 5; where 1 = tiny, 2 = small, 3 = normal, 4 = big and 5 = huge.

The dataset contained 2,381,200 calving records across all breeds available from 1986 to 2016. Inbreeding coefficients and the proportion of known ancestors per generation were calculated for animals in the associated pedigree file using VanRaden's method (1992) implemented through the Fortran package Pedig (Boichard D., 2002).

The analyses were done within breed. Only animals with a single calving observation per year with complete information on calf sex, calf fate, calving difficulty and size of calf were included in the analysis. Age at calving was restricted to 18-34 months for heifers and

greater than 34 months for cows. Outliers were filtered out for age at calving in cows by a criterion linked to the number of records, specifically if it is more than  $k$  standard deviations away from the trait mean, where  $k = |\Phi^{-1}(1/n)|$ ,  $n$  is the number of data records, and  $\Phi^{-1}(\cdot)$  is the inverse cumulative distribution function of a standard normal distribution (Aggarwal, 2013). As a result, calving's after 14 years for Jerseys and 16 years for Holsteins were excluded.

### Statistical Analysis

The analysis was done with linear models in Asreml (Gilmour *et al.*, 2009). To test the effects of inbreeding, data were divided into pedigree completeness of 75% or greater for 3 generations of pedigree. If inbreeding was significant, the three generation subset was used, otherwise full dataset was used.

After preliminary analysis, the model used was:

$$y_{ijklm} = \mu + \text{sex}_i + \text{CE}_j + \text{size}_k + \text{hys}_m + e_{ijklm}$$

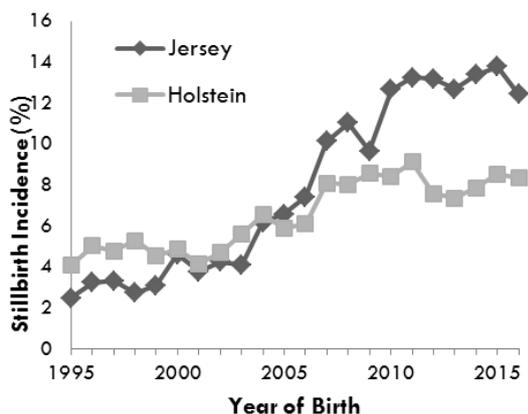
Where  $y_{ijklm}$  was SB,  $\mu$  was the intercept, fixed effects were; sex of calf, calving ease score, size of calf and herd-year-season;  $e_{ijklm}$  was the residual term and was assumed to be normally distributed  $e_{ijklm} \sim N(0, \sigma^2)$ . Additionally, age of dam at calving was fitted in heifers as a covariate (linear and quadratic); the fixed effect for month of calving for jersey heifers; and inbreeding as a covariate for the direct inbreeding coefficient in Holstein heifers.

## Results

The occurrence of SB in Holstein and Jersey heifers and cows are shown in Table 1. Stillbirth was considerably higher in heifers than cows in both breeds. When comparing breeds, Jerseys had consistently higher SBs than Holsteins, yet 96.8% calved without assistance. When assessing the rates of SB over a 20-year time period (Figure 1), Jerseys had greater increases in SB, from 2.5% in 1995 to 13.8% in 2015, compared with Holsteins which increased from 4% to 8.5% during the same period.

**Table 1: The incidence of stillbirth (SB) and calving difficulty (CD) in Jerseys and Holsteins**

| Breed of cow/status | Number | % SB | % Any CD |
|---------------------|--------|------|----------|
| Jersey heifers      | 5800   | 13.0 | 5.7      |
| Jersey cows         | 50433  | 7.9  | 2.9      |
| Holstein heifers    | 39255  | 11.8 | 21.1     |
| Holstein cows       | 347296 | 5.0  | 9.0      |



**Figure 1: The rate of stillbirth by birth year from 1995 to 2016 in Australian Jerseys and Holsteins**

Similar rates of inbreeding have been observed in both breeds from 2000-2016 (0.10 vs 0.11; Table 2) whilst Jerseys on average had higher inbreeding coefficients (3.0% vs 2.3%).

The relative sizes of fixed effects of inbreeding, CD, calf size and sex on SB are shown in Table 3.

**Table 2: The rate of inbreeding by birth year from 2000 to 2016 in Australian Jerseys and Holsteins with at least 3 generations of complete pedigree (>75%)**

|           | Holstein | Jersey |
|-----------|----------|--------|
| 2000-2008 | 0.12     | 0.17   |
| 2009-2016 | 0.06     | 0.04   |
| 2000-2016 | 0.10     | 0.11   |

Inbreeding had a negative effect on SB in Holstein heifers. There was no significant effect of inbreeding on SB in Jerseys. Trends in calving difficulty were similar across breeds in all cases, where assisted calving's decreased the probability of a live born calf. Although, the majority of Jersey calves were born unassisted, experiencing an extreme difficulty (4) increased their chance of death in both heifers and cows by 79 to 82% compared to those born normally. In Holsteins, the difference was only about half of that (Table 3).

## Discussion

Identifying the factors that affect SB has both economic and welfare importance in dairy production. Until recently, the Australian dairy industry has had limited access to sufficient calving performance records. The number of records available is expected to increase as more data can be exported off farms and into a centralized database being developed by DataGene. This study is a preliminary analysis for the development of SB breeding values for Australian Jerseys and Holsteins. We have observed that factors that have a significant influence on SB vary between breeds and heifers and cows.

The increase in SB rate observed in Australian cattle agrees with the global trend (Harbers *et al.*, 2000). In Holstein heifers, the observed incidence of SB was lower than reported by Meyer *et al.* (2001) and Harbers *et al.* (2000) (4.8% vs. 11.1-13.2%) at a similar time period and comparable to estimates reported by Eaglen *et al.* (2012) (11.8% for heifers and 4.3% for cows) and Yao *et al.* (2014). Few studies have documented the incidence and

rates of SB in Jerseys and this is the first Australian study to do so. The incidence of SB was greater in Australian Jerseys than both the USA and Danish populations (Norberg *et al.*, 2013, Yao *et al.*, 2014). Although, part of the increase in rate and incidence of SB in Australia could be due to improved data recording in recent years, SB is higher than any other documented Jersey population.

The level of inbreeding has doubled for both breeds in the past 15 years. These trends are similar to those observed in the USA (CDCB, 2017); however Australian Jerseys and Holsteins are considerably less inbred. This difference could be explained by the level of pedigree completeness between the countries. For example, only 51.9% of animals in this study had three generations of complete pedigree information whilst the USA reported 97.7% of Holsteins were complete for five generations (Cassell *et al.* 2003).

Although more complete pedigrees are preferred, for calculating inbreeding using pedigree, having three generations of recorded ancestry enabled detection of a significant effect of inbreeding on SB in Holstein heifers. Another approach could be to use genomic data to calculate inbreeding coefficients, as this eliminates the issue of pedigree depth.

However, none of the SB calves in this study were genotyped and only a small proportion of the contemporaries.

Calving difficulty has previously been reported to be a major cause of SB in Holsteins (Adamec *et al.*, 2006), yet more than half of all stillbirths are from unassisted calvings. Few studies have described the impact of inbreeding on calf survival; however, findings from this study indicate that inbreeding has significant effects on the fate of the calf in Holstein heifers and could explain deaths not associated with calving difficulty.

Interestingly, for Jerseys, inbreeding was not significant. One potential reason for this could be due to the limited number of records used for Jerseys in this study and the type of model used. A linear model was used which may be a limitation of this study. Statistically, conversion to a threshold model may be more appropriate as it is a binary trait (Eaglen *et al.*, 2012), however, the low incidence of SB causes problems with conversion (Pryce *et al.*, 2006).

We therefore chose to evaluate modelling possibilities using linear models rather than threshold models.

## Conclusions

The rates and incidence of SB in Holsteins were generally similar, or less, than those reported in other studies, whilst SB in Jerseys was higher. We have determined that inbreeding has significant effects on the fate of the calf in Holstein heifers and could explain some SB not associated with calving difficulty.

**Table 3: Fixed effects of inbreeding, calving difficulty, calf size and sex on stillbirth for both heifer and cow calving's in Jerseys and Holsteins.**

|                                 | Heifers                   |                | Cows                     |                |
|---------------------------------|---------------------------|----------------|--------------------------|----------------|
|                                 | Jersey                    | Holstein       | Jersey                   | Holstein       |
| <b>Inbreeding</b>               | NS                        | -0.20±0.088*   | NS                       | NS             |
| <b>Calving Difficulty Level</b> |                           |                |                          |                |
| <b>Without</b>                  | 0                         | 0              | 0                        | 0              |
| <b>Slight</b>                   | -0.34±0.031***            | -0.13±0.006*** | -0.33±0.011***           | -0.08±0.002*** |
| <b>Moderate</b>                 | -0.59±0.030***            | -0.38±0.008*** | -0.56±0.011***           | -0.32±0.003*** |
| <b>Extreme</b>                  | -0.82±0.058***            | -0.39±0.020*** | -0.79±0.025***           | -0.43±0.007*** |
| <b>Sizes</b>                    |                           |                |                          |                |
| <b>Tiny</b>                     | -0.32±0.054*              | -0.45±0.026*** | -0.47±0.018***           | -0.49±0.008*** |
| <b>Small</b>                    | -0.07±0.023*              | -0.05±0.009*** | -0.10±0.007***           | -0.08±0.004*** |
| <b>Normal</b>                   | 0                         | 0              | 0                        | 0              |
| <b>Big</b>                      | -0.02±0.030 <sup>NS</sup> | -0.03±0.008**  | 0.01±0.007 <sup>NS</sup> | -0.01±0.002**  |
| <b>Huge</b>                     | -0.11±0.110 <sup>NS</sup> | -0.12±0.023**  | 0.01±0.024 <sup>NS</sup> | -0.01±0.004*   |
| <b>Sex</b>                      |                           |                |                          |                |
| <b>Male</b>                     | -0.14±0.011*              | -0.10±0.005*** | -0.09±0.003***           | -0.04±0.001**  |
| <b>Female</b>                   | 0                         | 0              | 0                        | 0              |

\*\*\* is P<0.001, \*\* is P<0.01, \* is P<0.05, <sup>NS</sup> is Non Significant

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# HIGH GENETIC MERIT COWS MAKE GREATER CONTRIBUTIONS TO FARM PROFIT

Jo Newton<sup>1</sup>, M.E. Goddard<sup>1,2</sup>, H.N. Phuong<sup>1</sup>, M.A. Axford<sup>3</sup>, C.K.M. Ho<sup>1</sup>, N.C. Nelson<sup>1</sup>, C.F. Waterman<sup>1</sup>, B.J Hayes<sup>1,4</sup> and J.E Pryce<sup>1,5</sup>

<sup>1</sup>Department of Economic Development, Jobs Transport and Resources, Victoria, Australia

<sup>2</sup>University of Melbourne, Parkville, Victoria, 3010, Australia

<sup>3</sup>DataGene Ltd, Bundoora, Victoria, 3083, Australia

<sup>4</sup>Centre for Animal Science, University of Queensland, Queensland, Australia.

<sup>5</sup>La Trobe University, Bundoora, Victoria, 3083, Australia

Corresponding author jo.newton@ecodev.vic.gov.au

## Abstract

The rate of genetic progress made in the Australian dairy industry is less than half of what is theoretically feasible. One of the barriers to adoption of Australian Breeding Values (ABVs) is a lack of evidence that high genetic merit dairy cows contribute more to farm profit in practice. Using historical financial data collected as part of the Dairy Farm Monitor (DFM) Project, and historical cow production, health and mating records, a method was developed to estimate the contribution each cow in a herd made to farm profit over her lifetime. For each of the three herds in this study, cows were then ranked on genetic merit using the Balanced Performance Index (BPI) and classified into low and high BPI sub-herds. A linear model weighted by cow productive life was used to test for differences in annualized physical and financial measures of cow performance in the low and high BPI sub-herds. High genetic merit cows contributed between \$165 and \$239 per cow more to farm profit each year without compromising their productive life, or incurring higher breeding or mastitis treatment costs. Although high genetic merit animals had higher feed costs, these were more than compensated for by greater milk income. These case studies will contribute to localised extension activities and help build the dairy industry's trust, knowledge and use of ABVs.

## Introduction

The Australian dairy industry is making genetic progress. However, the actual rate of genetic gain is less than half of what is theoretically feasible (Schaeffer 2006). The ImProving Herds project was established with the goal of improving farm profit through demonstrating the value of genetics and herd improvement in the dairy industry. This was a key goal recognised in the National Herd Improvement 2020 Strategy. Additionally, Dairy Australia recommended that increased focus be placed on case studies and regionally specific extension activities to increase knowledge, trust

and use of genetic tools in the dairy industry. To incorporate this suggestion, the ImProving Herds project works closely with around 34 focus farms.

A study of Irish dairy herds found a relationship between higher herd genetic merit and greater net margin per cow, even after differences in year, stocking rate, herd size and purchased feed were accounted for (Ramsbottom *et al.* 2012). The Australian dairy industry is not suited to an across herd economic analysis. Climatic variability, diverse feeding and management practices and variability in milk payment systems exacerbate

between herd variations in economic performance.

To control for this variability, a within herd analysis, using focus farms from the ImProving Herds project as case studies was undertaken. The aims of this study were to 1) develop a method to calculate the contribution an individual cow makes to farm profit over her lifetime, and 2) investigate the relationship between cow genetic merit, profit and performance at the individual farm level.

## Materials and Methods

Two independent databases were used in this study of 3 Victorian dairy farms: 1) the DFM project database; a joint initiative between Agriculture Victoria and Dairy Australia which collects and analyses in-depth financial and production data from dairy farms, and 2) DataGene; the national database of dairy cow production, mating, health, pedigree and ABV records.

Within-herd long-term averages over the 2008 to 2016 financial years, inclusive, were calculated for farm financial data, adjusted to present day values, and herd production data. To be included in this analysis, a cow's entire productive life had to fall within the 2008 to 2016 financial years. The contribution each cow made to farm profit over her lifetime (Cow\$) was calculated using the equation:

$$\text{Cow\$} = \$_{\text{milk}} + \$_{\text{calf}} + \$_{\text{cull}} - (\$_{\text{rear}} + \$_{\text{feed}} + \$_{\text{mastitis}} + \$_{\text{repro}} + \$_{\text{herd}})$$

Lifetime milk income ( $\$_{\text{milk}}$ ) was calculated by multiplying total milk solids (MS) by average milk price ( $\$/\text{kg MS}$ ). Income from calf sales ( $\$_{\text{calf}}$ ), and costs of mastitis treatment ( $\$_{\text{mastitis}}$ ) and animal mating ( $\$_{\text{repro}}$ ) were calculated by summing the number of incidences of each event and multiplying by the dollar value, in  $\$$  per cow, of one occurrence of that event. A cow's salvage value ( $\$_{\text{cull}}$ ) was taken as the average within-herd cull cow price unless she was recorded as dead, when it was  $\$0$ . If more than 12 months had passed since the cow was last seen in the herd she was assumed to have been sold. The cost of rearing each cow to the point of entering the milking herd ( $\$_{\text{rear}}$ ) was assumed to be  $\$1606$  (Byrne *et al.* 2016).

Feed costs were calculated by multiplying the within-herd average cost of feed consumed ( $\$/\text{Megajoule of metabolisable energy}$ ,  $\$/\text{MJ}$

ME) by each cow's energy requirements. Cow energy requirements were calculated using the equations in CSIRO (2007). This accounted for cow age and breed, lactation and pregnancy records and herd level information about distance walked each day, farm topography, liveweight and condition score loss during lactation. Remaining herd costs ( $\$_{\text{herd}}$ ) were assumed to be proportional to the cow's productive life. Day 1 was taken as the date of first calving. To account for discounting over time, all elements of the profit equation were calculated in 365 day periods, a 5% discount rate applied and then summed together.

The ABVs published by DataGene are breed specific. The 3 herds had Holstein (Herd C), Jersey (Herd A) and mixed Jersey and Holstein (Herd B) cows. The original ABV solutions were obtained from multi-breed models and rescaled using the Holstein ABV parameters, enabling a within-herd, but across breed analysis to be used. The BPI is the Australian dairy industry's main index.

It was developed using a bio-economic model to balance improvements in longevity, health, type, fertility and production to maximise farm profit (Byrne *et al.* 2016). For this study, within each herd each cow was classified into two sub-herds, either low or high BPI based on whether she was below or above the median BPI for her contemporary group; herd and year of first calving. A linear model weighted by cow productive life (in days) was used to test for differences in annualized physical and financial measures of cow performance in the low and high BPI sub-herds.

This analysis was performed separately for each herd. The results below are presented as the estimate of the difference between the two sub-herds within each of the 3 herds from the weighted linear model.

## Results and Discussion

In all 3 herds, splitting the herd based on median BPI resulted in significant ( $p < 0.05$ ) differences between the high and low BPI sub-herds (Table 1). The difference in BPI between the two sub-herds ranged from  $\$78$  to  $\$116$ . All high BPI sub-herds had significantly ( $p < 0.001$ ) higher BPI and milk production and survival ABVs than the below BPI sub-herds (Table 1).

Cows in the high BPI sub-herds produced significantly ( $p < 0.05$ ) more litres of milk, and kilograms of fat and protein each year than their low BPI counterparts (Table 2). All high

BPI sub-herds tended to have cows with a longer productive life, but this difference was only significant ( $p < 0.05$ ) for 1 herd.

**Table 1 Estimated difference (high BPI – low BPI) (s.e) in ABVs between high and low BPI sub-herds from weighted linear model.** Significance of p-value (NS  $> 0.05$ , \* =  $< 0.05$ , \*\* =  $< 0.01$ , \*\*\* =  $< 0.001$ )

| Herd | BPI        | Protein ABV | Milk ABV    | Fat ABV   | Cell count ABV      | Fertility ABV       | Survival ABV |
|------|------------|-------------|-------------|-----------|---------------------|---------------------|--------------|
| A    | 78 (5)***  | 10 (1)***   | 269 (71)*** | 17 (2)*** | 3 (2) <sup>NS</sup> | 0 (1) <sup>NS</sup> | 2 (0)***     |
| B    | 94 (6)***  | 13 (1)***   | 376 (66)*** | 18 (2)*** | 6 (2)**             | -1 (1)*             | 2 (0)***     |
| C    | 116 (4)*** | 14 (1)***   | 340 (45)*** | 21 (2)*** | 3 (1)*              | -1 (0)**            | 3 (0)***     |

**Table 2 Estimated difference (high BPI – low BPI) (s.e) in physical parameters between cows in high and low BPI sub-herds from weighted linear model.** Significance of p-value (NS  $> 0.05$ , \* =  $< 0.05$ , \*\* =  $< 0.01$ , \*\*\* =  $< 0.001$ )

| Herd | Milk (L/yr)    | Fat (kg/yr)  | Prot (kg/yr) | Productive life (months) |
|------|----------------|--------------|--------------|--------------------------|
| A    | 434<br>(154)** | 26<br>(6)*** | 19<br>(5)*** | 4<br>(3) <sup>NS</sup>   |
| B    | 411<br>(131)** | 20<br>(5)*** | 19<br>(4)*** | 5<br>(3) <sup>NS</sup>   |
| C    | 265<br>(125)*  | 27<br>(4)*** | 19<br>(4)*** | 4<br>(2)*                |

All high BPI sub-herds were significantly ( $p < 0.01$ ) more profitable, with the average difference ranging from \$165 to \$239 per cow/year (Table 3). The main source of this difference was greater yearly milk income, with cows in high BPI sub-herds generating on average between \$185 and \$258 more income from milk sales each year. Although

feed costs were higher in the high BPI sub-herds, the extra cost of feed ranged from \$30 to \$42, which was more than compensated for by additional milk income.

Increases to milk income were achieved without decreasing, and in one case significantly ( $p < 0.05$ ) increasing, the average productive life of the high BPI sub-herds (Table 2) and without significantly ( $p > 0.05$ ) increasing mastitis costs (Table 3). This finding goes some way to dispel the widely-held belief that high producing animals break down earlier and are more prone to mastitis.

At the national level the regression of profit and BPI is expected to be a \$1 increase in profit for every unit increase in BPI (Byrne *et al.* 2016). In the three case study herds, the ratio between Cow\$ and BPI was higher than this at \$2.49, \$1.76, \$2.06 for herds A, B, C respectively. This differs from Ramsbottom *et al.* (2012) whose €1.94 increase in net margin per cow was very close to the expected increase of €2.00 (in Ireland breeding values are presented as Predicted Transmitting Abilities that are half the estimated breeding value).

A possible reason is that the 3 Victorian herds in our study are not representative of the national average, whereas Ramsbottom *et al.*'s (2012) larger study of 1131 herds better captures the national variation in Irish dairy

herds. An indication this may be the case is that average feed cost for the herds in our study ranged from \$0.016 to \$0.022/ MJ ME whilst the national average purchased feed cost is \$0.025 /MJ ME (Byrne *et al.* 2016).

The phenotypic records used to calculate Cow\$ were also used in cow ABV estimation. An alternative approach that uses ABVs derived from parent average or genomic prediction could also be used. A parent average analysis was conducted, with similar results obtained to those reported here. Differences in Cow\$ between the sub-herds selected based on parent average BPI were significant ( $p < 0.05$ )

in two herds and approached significance ( $p < 0.1$ ) in the third herd. However, fewer cows have ABVs available for both parents than on themselves. In choosing which results to present, the end goal of the ImProving Herds project was considered. The goal of the ImProving Herds project is to increase knowledge, trust and usage of genetic tools, such as ABVs and the BPI, in the Australian dairy industry. For the purposes of demonstrating that ABVs “work” to farmers it is therefore most relevant to use the ABVs in the format they appear in existing industry tools.

**Table 3 Estimated difference (high BPI – low BPI) (s.e) in the contribution each cow makes to profit (Cow\$) and Cow\$ components between high and low BPI sub-herds from weighted linear model. Significance of p-value (NS >0.05, \* = <0.05, \*\* = <0.01, \*\*\* = <0.001)**

| Herd | Cow\$ (\$/yr) | Income  |                   |                    | Costs  |                   |                   |                    |
|------|---------------|---------|-------------------|--------------------|--------|-------------------|-------------------|--------------------|
|      |               | Milk    | Calf              | Cull               | Feed   | Reproduction      | Mastitis          | Rearing            |
| A    | 195           | 208     | -2                | -23                | -42    | 6                 | -3                | 52                 |
|      | (47)***       | (51)*** | (4) <sup>NS</sup> | (18) <sup>NS</sup> | (16)** | (5) <sup>NS</sup> | (3) <sup>NS</sup> | (44) <sup>NS</sup> |
| B    | 165           | 185     | -7                | -28                | -34    | -4                | -3                | 55                 |
|      | (39)**        | (43)*** | (4) <sup>NS</sup> | (22) <sup>NS</sup> | (12)** | (4) <sup>NS</sup> | (3) <sup>NS</sup> | (39) <sup>NS</sup> |
| C    | 239           | 258     | -10               | -16                | -30    | 6                 | 1                 | 31                 |
|      | (36)***       | (49)*** | (2)***            | (18) <sup>NS</sup> | (12)*  | (3) <sup>NS</sup> | (3) <sup>NS</sup> | (29) <sup>NS</sup> |

This analysis required in depth historical financial, pedigree, performance and management information from the case study herds. Not all focus farms have just depth in their data. A tiered approach is being developed which will enable this analysis to be undertaken on other herds that have cow ABVs but have less detailed cow production and management records.

Also being explored is the opportunity to use regional historical financial information for herds with less detailed financial data. This will mean it will be possible to conduct this analysis on a larger number of farms that are more representative of the wide range of herd sizes, feeding systems, farming systems and environments here in Australia.

## Conclusion

Although the BPI is derived used national figures this study has shown that the relationship between cow genetic merit and cow contribution to farm profit holds true at the individual farm level. High genetic merit cows make greater contributions to farm profit. Although high genetic merit cows have higher feed costs, these are more than compensated for by greater milk income. Furthermore, our analysis indicates that high BPI cows do not have a shorter productive life, nor higher mastitis incidence or mating costs. These case studies provide an opportunity to contribute to localised extension activities and help build the dairy industry’s trust, knowledge and use of ABVs.

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# MANIPULATING THE DIURNAL FEEDING BEHAVIOUR OF DAIRY COWS USING FEED TYPE AND QUANTITY

John, A.J.,\*<sup>1</sup> Garcia, S.C.,\* Kerrisk, K.L.,\* Freeman, M.J.,<sup>†</sup> Islam, M.R.,\* and Clark, C.E.F.\*

\*Dairy Science Group, School of Life and Environmental Sciences, Faculty of Science, The University of Sydney, Camden, New South Wales 2570

<sup>†</sup>Tasmanian Institute of Agriculture Dairy Centre, University of Tasmania, Burnie, Tasmania 7320

<sup>1</sup>Corresponding author: ajoh7559@uni.sydney.edu.au

## Abstract

The diurnal feeding patterns of dairy cows has a major influence on the 24 h robot utilisation of pasture-based automatic milking systems (AMS). Thus, understanding how feeding strategies can be used to manipulate diurnal feeding behaviour is essential to maximise the efficiency of AMS. This study determined the effect of temporal variation in feed quality and quantity as methods to increase cow feeding activity between 2400-0600 h. We offered Lucerne hay cubes (CP = 18%, WSC = 5.2%) and oat, ryegrass and clover hay cubes with 20% molasses (CP = 11.1%, WSC = 25.6%) as “standard” and “preferred” feed types respectively, across four 6 h feeding periods. The four treatments were: 1. standard feed offered ad-lib throughout 24 h (AL); 2. identical to AL, with preferred feed replacing standard feed between 2400-0600 h (AL+P); 3. standard feed offered at a restricted rate, with quantity varying between each 6 h feeding period (20:10:30:60% respectively) as a proportion of the measured daily ad-lib intake (VA); 4. identical to VA, with preferred feed replacing standard feed between 2400-0600 h (VA+P). Eight non-lactating dairy cows were used in a replicated 4x4 Latin square design. Each treatment lasted 7 days, including 3 days adjustment and 4 days data collection. Total daily intake was greater ( $P < 0.001$ ) for the AL and AL+P treatments (23.1 and 22.9 kg.DM) compared to the VA and VA+P treatments (21.6 and 20.9 kg.DM). The AL+P and VA treatments resulted in a 10% and 20% increase ( $P < 0.001$ ) in feed intake for the period between 2400-0600 h respectively, compared to the AL treatment, whilst the VA+P treatment provided no further increase in intake compared to the VA treatment. This study has shown the potential to increase cow feeding activity at night by varying feed type and quantity, which could improve robot utilisation in pasture-based AMS.

## Introduction

A thorough understanding of dairy cow feeding behaviour is required, in order to develop feeding strategies that increase the performance of modern dairy systems. Cattle are crepuscular, and as Gregorini (2012) highlighted, several factors that influence diurnal feeding behaviour include photoperiod, satiety hormones, diurnal variation in pasture quality and predatory instincts. The daily light cycle is theorised to regulate melatonin (hunger) and serotonin (satiety) levels (Gregorini, 2012), with melatonin regulating

several physiological pre-meal responses. Diurnal changes in forage nutritive value also make dusk the ideal time to graze (Delagarde *et al.*, 2000), with Horadagoda *et al.* (2009) showing dairy cows prefer forage with greater WSC content. Maximising rumen fill at dusk also provides a pool of slow release energy to last throughout the night (Gregorini, 2012), when predation is most likely to occur. All of these factors highlight the complexity governing the natural feeding behaviour of cattle.

Offering fresh feed is the main incentive used to encourage dairy cows to voluntarily traffic in a pasture-based AMS (Kerrisk, 2009). As a result, it is largely the animal's decision when to move to a new paddock, often causing robot utilisation to be variable throughout 24 h, as dairy cows prefer to rest during the night. John *et al.* (2016a) highlighted the link between feeding patterns and robot utilisation in AMS and demonstrated the potential to improve robot utilisation by manipulating diurnal feeding patterns to be more uniform throughout 24 h. However, our understanding of how varying feed quantity and quality throughout 24 h impacts cow feeding patterns, is limited.

Where feed quantity has been manipulated at the robot (8kg vs. 3kg of concentrate per day), no difference in MY, MF, number of cows fetched or DMI has been observed (Bach *et al.*, 2007), suggesting the manipulation of feeding behaviour requires feed to be independent from the robot. A study by John *et al.* (2013) showed that a farmer offering varying quantities of feed in each of three daily allocations achieved consistent robot utilisation throughout 24 h. Pasture was allocated in a

**Table 1. Feed offered in each period for the four treatments**

| Feeding Period | AL  | AL+P | VA   | VA+P |
|----------------|-----|------|------|------|
| 0600 – 1200    | L ∞ | L ∞  | L 20 | L 20 |
| 1200 – 1800    | L ∞ | L ∞  | L 10 | L 10 |
| 1800 – 2400    | L ∞ | L ∞  | L 30 | L 30 |
| 2400 – 0600    | L ∞ | P ∞  | L 60 | P 60 |

AL = Ad-lib treatment, AL+P = Ad-lib treatment with preferred feed, VA = Variable allocation treatment, VA+P = Variable allocation treatment with preferred feed, L = Standard feed (Lucerne); P = Preferred feed (Oat/Rye/Clover +20% Molasses); ∞ = Ad-lib; n = % of daily allocation

40% : 40% : 20% ratio, with the small allocation occurring between 1700 and 0200 h. It is likely the smaller pasture allocation at dusk provided incentive for the cows to seek out fresh feed between midnight and 0600 h, as the previous allocation is likely to have been depleted more rapidly.

The aim of this experiment was to test the impact of “variable allocation”, where the largest allocation occurred at night, and “variable feed quality”, where a high WSC feed was offered at night, on the feeding behaviour of dairy cows. We hypothesized that the DMI of cows can be increased, during the period from 2400 to 0600 h, by changing the temporal allocation of feed in both quantity and type of feed offered. This could potentially be used to encourage dairy cows to seek out new feed in pasture-based AMS.

## Materials and methods

### Animals and Treatments

Use of animals was approved by the University of Sydney's Animal Ethics Committee (2015/905). The study was conducted between 13 October and 16 November 2016 at the University of Sydney research farm 'Mayfarm'. The light and dark cycle was approximately 13h and 11h with sunrise and sunset occurring at approximately 0600h and 1900h, respectively. The mean ( $\pm$ SD) minimum and maximum temperature was 10.9 ( $\pm$ 3.8) and 26.5 ( $\pm$ 3.7) °C respectively.

Eight non-lactating, Holstein-Friesian dairy cows (659  $\pm$  103 kg liveweight, 88  $\pm$  32 mo old, , 4.1  $\pm$  2.3 lactation number, 156  $\pm$  28 d pregnant, mean  $\pm$  SD) were used. The experiment duration was 28 d, divided into four periods of 7 d in a 4x4 Latin square design. Each period consisted of 3 d of adjustment, followed by 4 d of data collection.

Each day had 4 feeding periods and depending on the assigned treatment, the cows were offered lucerne cubes either ad-libitum or restricted, in combination with offering a “preferred” feed cubes in feeding period 2400-0600 h (Table 1). To maintain an ad-libitum feed state (for AL and AL+P treatments), dairy cows were offered 13.5 kg of DM at the start of each feeding time. Feed was weighed and replenished at the end of each feeding period.

Lucerne hay cubes (DM = 88.7%, NDF = 46.4%, CP = 18%, WSC = 5.2%, ME = 9.4 MJ/kg of DM) were offered as the “standard” feed and oat/rye grass/clover hay cubes with 20% molasses powder (DM = 88%, NDF = 31.2%, CP = 11.1%, WSC = 25.6%, ME = 10.8 MJ/kg of DM) were offered as the

“preferred” feed. Dairy cows were randomly assigned to 4 treatments ( $n = 2$  dairy cattle per treatment) 7 d prior to the experimental period.

Intake for this period were used to calculate the restricted diet for the start of the trial, with the ad-lib intake for the last 4 d of each ad-lib treatment being used to calculate the feed allocation for the restricted treatments in the following week. Sixty percent of daily intake was offered in the 2400-0600 h period for VA and VA+P treatments so that restriction only applied within a “period”. Pens measured 30x10m in dimension, located outside, and each separated by a two-wire fence. Water was available ad-libitum in each pen. Pens were mown on the first day of each period to ensure the hay cubes offered were the only source of DM.

### Feed Samples

Fresh feed samples were collected daily for DM analysis, dried at 70°C for 48 h. Pre- and post-feeding feed weight was recorded for each cow and each feeding period. The difference between pre- and post-feeding feed weight determine gross intake per cow for each feeding time and was converted to DM intake using the DM measured from the corresponding days feed sample.

### Statistical Analysis

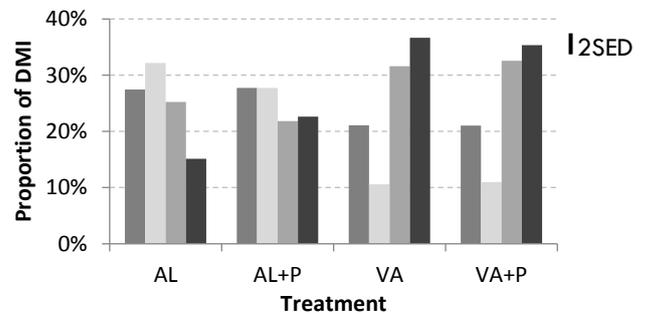
The proportion of daily intake occurring in each of the four feeding periods for each treatment was compared using REML variance components analysis with treatment and feeding time as fixed effects, and cow, nested within day, nested within week, as random effects.

Total daily intake was also compared between treatments using REML variance components analysis, with treatment as the fixed effect and cow, nested within day, nested within week, as the random effect.

### Results

Daily DMI was significantly larger ( $P < 0.001$ ) for the ad-lib treatments (AL = 23.1 and AL+P = 22.9 kg.DM) compared to the restricted treatments (VA = 21.6 and VA+P = 20.9 kg.DM).

The proportion of total daily intake (PI) consumed per feeding period for each treatment is presented in figure 1. Within the 2400-0600 h period, PI was greater for the AL+P treatment compared to the AL treatment, whilst the VA and VA+P treatments recorded between 1.6 to 2 times greater PI than the AL and AL+P treatments respectively.



**Figure 1. Proportion of total daily intake consumed for each treatment for the 0600-1200 h (■), 1200-1800 h (□), 1800-2400 h (▨) and 2400-0600 h (▩) periods.**

### Discussion

The objective of this study was to determine if offering multiple feed types (preferred feed) and strategic allocation of feed quantity (variable allocation) throughout 24 h could be used to increase feeding activity in the period between 2400-0600 h. The AL treatment provided our baseline “natural” feeding behaviour. The dairy cows followed a typical diurnal feeding pattern under AL conditions, with the greatest PI coinciding with dusk (1200-1800 h) and the lowest PI occurring at night (2400-0600 h), in line with the observations of Gregorini (2012).

The AL+P treatment resulted in a desirable change in diurnal feeding pattern, with cows redistributing their DMI across the four feeding periods, resulting in a larger proportion of DMI occurring in the 2400-0600 h period. We attribute this increase in DMI between 2400-0600 h to the cows preference to consume feed with greater WSC levels. Grazed soya bean (WSC = 10.0%) has previously been offered in kikuyu based AMS (WSC = 8.5%), with no improvement in MY or voluntary cow traffic (Clark *et al.*, 2014).

It is possible, the difference in WSC between the two feeds, being much lower than in our experiment, was insufficient to alter the feeding behaviour of the dairy cows. Further,

the soya bean was also offered during the day. We suggest offering a “preferred feed” during the night could increase motivation of cows to search for fresh feed at night, with further research required to confirm this hypothesis.

The feed intake pattern of the cows was effectively inverted on the VA treatment. The VA treatment achieved the greatest PI between 2400-0600 h out of all treatments, driven by varying the quantity of feed offered throughout 24 h. The study by Dalley *et al.* (2001), whereby offering six equal allocations of pasture in 24 h (including one at 0330 h) only increased feeding activity between 2200 and 0600 h by 2%, highlights the importance of varying the quantity of feed allocated, as in our experiment, rather than just offering a new allocation of feed at night. Also, offering an additional allocation of pasture (totaling three allocations per day), has been shown to have minimal effect on robot utilisation between 2400-0600 h (Lyons *et al.*, 2013). Finally, a study of two pasture-based AMS farms utilising contrasting methods of variable allocation, found only one farm achieved a consistent level of robot utilisation throughout 24 h (John *et al.* 2013). This suggests the precise way feed quantity is varied throughout 24 h is equally important in order to increase feeding intensity at night.

Combining both preferred and variable feeding into a single treatment (VA+P) provided no additional increase to DMI between 2400-0600 h, compared to the VA treatment. The dairy cows on both the VA and VA+P treatments consumed on average 36% of their daily intake (approximately 7.8 kg.DM), rather than the 40% targeted, between 2400-0600 h.

Time was not a limiting factor as a similar study observed maximum intake of 14.1 kg.DM for a single 6 h period (John *et al.*, 2016b). Rather, it is likely that the cows compromised DMI in favour of resting between 2400-0600 h, with the addition of a preferred feed unable to further increase the cows desire to feed. The strong desire to rest at night is seen in the study by Helmreich *et al.* (2014), where dairy cows fed ad-lib in an indoor AMS allocated only 15% of their total daily feeding time to the period between 2200 to 0500 h, instead, spending the majority of this period in the lying area.

With these points in mind, no more than 35% of the total daily ration should be allocated between midnight and 0600 h when implementing a variable allocation strategy on farm. If the quantity of feed allocated can be correctly balanced amongst the daily feed allocations in an AMS then any reduction in DMI should be minimal, and be offset by higher robot utilisation and milk yield.

## Conclusions

Our study shows how variable allocation and variable feed type can be used to manipulate the diurnal feeding behaviour of non-lactating dairy cows. Variable allocation offers the most potential to increase robot utilisation and could be adapted into current pasture-based AMS with a simple change in pasture management. Further work testing this concept on farm is required to determine if variable allocation can improve robot utilisation and if so, how to optimise such a management strategy.

## Acknowledgements

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# INVESTIGATION INTO THE IMPACT OF A PERIOD OF SEMI-BATCH MILKING IN A PASTURE-BASED AUTOMATIC VOLUNTARY MILKING SYSTEM.

**Juan Molfino<sup>C</sup>, Kendra Kerrisk and Sergio García**

*Dairy Science Group, School of Life and Environmental Sciences, Faculty of Science, The University of Sydney Camden, New South Wales, Australia*

<sup>C</sup>Corresponding author Email: [juan.molfino@sydney.edu.au](mailto:juan.molfino@sydney.edu.au)

## **Abstract**

*Pasture-based automatic milking systems operating with voluntary cow traffic, with either seasonal or split calving systems are likely to have a period of equipment underutilization due to reduced herd size and subsequent low cow:robot ratios. During these periods it is expected that operating costs are increased and labour efficiency is reduced. Operating a semi-batch traffic system during this period could address these issues, however the ability of experienced cows to shift from semi-batch milking back to voluntary milking without significant negative impacts on cow performance have not been investigated to date. Cow performance data was collected over a 24-week period from a farm in Tasmania, where 156 cows were milked by an automatic milking robotic rotary. For the first 8 weeks cows were allowed to traffic voluntarily with a 3 way grazing system, followed by 8 weeks where cows were milked twice a day and managed under a semi-batch trafficking systems before reverting back to 3 way grazing for the last 8 weeks. Results indicate that experienced cows can be transitioned from semi-batch milking and back to voluntary milking without significant negative impacts on cow performance. This is a management strategy that can be employed during periods of underutilisation to improve both milk harvesting and labour efficiencies.*

## **Introduction**

Cow traffic has been recognized as one of the key factors affecting the feasibility and operational efficiency of automatic milking systems (AMS)(Lyons *et al.* 2013). In Australia the majority of pasture-based AMS use controlled voluntary cow traffic, where cows can move from the paddock and through the dairy (with pre-selection for milking if milking permission is granted) to the next feed allocation by themselves. At certain times of the year, AMS farms that operate a voluntary traffic system with either seasonal or split calving systems are likely to have some months where the number of cows per robot is

particularly low. This can present some challenges such as difficulty to achieve and maintain good voluntary cow movement with the reduced herd size, reduced labour use efficiency, under-utilisation of the milk harvesting equipment, higher operating costs (per litre of milk), and sometimes creates challenges with maintaining high milk quality.

With box-robot operations some of these challenges can be addressed by operating with a reduced number of boxes (i.e. with some boxes turned off for certain period of time) to maintain a relatively consistent cow:box ratio. With the DeLaval Automated Milking Rotary

(AMR™), the operator does have the possibility to deactivate some of the bails (Kolbach *et al.* 2013) on the platform which might address some of the above-mentioned challenges but certainly not all of them.

Regardless of the type of robotic milk harvesting equipment some benefits might be realised if the operator can switch to a semi-batch milking mode (cows are allowed to walk to the dairy by themselves after an automatic gate releaser opens the paddock gate at designated times during the day or night) for the months of underutilisation. A management strategy such as this will give the operator the opportunity to turn on the milk harvesting equipment for defined hours, saving electricity, controlling milking frequency of the cows and increasing labour efficiency (it would negate the need for on-call staff during the night hours if the dairy was shut down). In addition, having the dairy shut down for a period of time creates the opportunity to do major services to the equipment before the commencement of the next calving season without negatively impacting cow traffic.

Whilst it is known that it can take some time for naïve cows to fully adapt to voluntary cow traffic (depending on herd size, machine capacity, pre-training and other factors)(Donohue *et al.* 2010) there is currently no published studies which demonstrates the ability of experienced cows to shift from semi-batch milking to voluntary milking within the same lactation and the effect that this might have on individual cow performance. A field study was conducted in a commercial farm to investigate the effects of implementing semi-batching system (cows were transitioned from a voluntary trafficking system to a semi-batch system and back to voluntary) on the subsequent performance and voluntary traffic of the individual cows. The knowledge generated will be used to guide the need for ongoing research and the development of management guidelines for Australian AMS farmers.

## Materials and Methods

### General information

The study was conducted in a commercial farm located in Deloraine (Tasmania) between April 27 and October 9 2015, where all milkings were performed by an AMR™. The farm has operated as a pasture-based system with voluntary cow traffic and 3-way grazing (3WG) (Lyons *et al.* 2013) since 2012. The data collection period extended over 24 weeks and was divided into 3 periods: Voluntary 1 (**VOL1**; weeks 1 to 8), Semi-batch (**SB**; weeks 9 to 16) and Voluntary 2 (**VOL2**; weeks 17 to 24).

During VOL1 and VOL2 cows were managed with 3WG and were allowed to voluntary traffic from pasture to the milk harvesting facility to be milked at any time during the day and night. Cows exiting the dairy after being milked or when denied milking permission, had access to one of the 3 daily pasture allocations, depending on the time of the day. Under VOL1, allocations opened at 0600 h, 1400 h, and 2200 h and under VOL2 at 0500 h, 1300 h, and 2100 h. Cows were granted milking permission based on a minimum milking interval of 6 hours or an expected yield greater than 7 kg/milking.

During the SB period cows were milked in two defined sessions/day commencing at 0500 h and at 1400 h. Cows were held in the paddock (gate closed) until 2 hours prior to the beginning of each milking session when an automatic gate releaser was activated. This meant that cows could traffic voluntarily to the dairy via the feedpad area from 0300 h and 1200 h with milking commencing at 0500 h and 1400 h respectively. Any cow not walking voluntarily to the feedpad area was fetched to the dairy before the milking session was finished. Cows were also encouraged to walk from the feedpad area and through the waiting yard as required to ensure that the milking sessions were generally completed by 0800 h in the morning and 1700 h in the evening. After being milked, cows were allowed to voluntary walk to the new

allocation of pasture and were locked after the milking session was complete.

For all periods target daily dry matter intakes were 22.5 kg DM/cow, and feed was offered as a combination of grazable pasture (*Lolium perenne*), partial mixed ration (PMR) and concentrate. The percentage of each feed in the daily allocation varied depending on the availability of pasture. At all times cows were managed as a single herd. In all 3 periods cows had access to grain based concentrate (GBC) feed after milking in 20 automated out-of-parlour feeders located in an area immediately post-milking. Individualised GBC was based on days in milk.

The autumn calving herd consisted of 199 Holstein-Friesian primiparous (n=43) and multiparous (n=156, parity range 2 – 8) cows. Only multiparous cows were included in the study, all of which had previous experience with 3WG system. At the beginning of the experiment (week 1) the herd was comprised of 86 cows and by week 6 all 156 cows had calved.

### **Data collection**

Data were collected electronically by the herd management software, including daily milking frequency (**MF**; milkings/cow/day), milk yield per day (**MYD**; kg/cow/day), milk yield per visit (**MYV**; kg/cow/visit), concentrate consumption (**CC**; kgDM/cow/day), percentage of concentrate consumed (**%CC**; %, defined as the proportion of allocated concentrate that was actually consumed/day); incomplete milkings (**INC**; %, defined as the proportion of milking events whereby one or more teats were either not milked or yielded less than 50% of the calculated expected yield); parity number, and days in milk. Due to the variability (between days) typically observed in AMS, seven-day averages were calculated prior to statistical analysis.

### **Statistical analysis**

The outcome variables analysed at cow level were milking frequency, milk yield per day, milk yield per visit, concentrate consumption, percentage of concentrate consumption and

incomplete milkings. The main explanatory variables included in the analyses were: days in milk, lactation number, traffic system (VOL1, SB, VOL2), concentrate consumption and cow ID. Linear mixed models (REML) were used to analyse data. All models included the fixed effects of days in milk, lactation number and traffic system.

The interactions between days in milk and lactation number with traffic system were tested, and if they were not significant they were removed from the model. For the analysis of MYD, concentrate consumption was included in the model as an interaction with traffic system. Cow ID was included as a random effect in all models. Residual analysis was performed to check for normality.

All analyses were conducted in Genstat 16th Edition (VSN International Ltd.) P values lower than  $P < 0.001$  were considered significant. Least significant differences were produced to calculate the location of any significance difference.

### **Results**

Both MYD and MF were similar before and after SB, but were reduced during the SB period (Table 1). Concentrate consumption was slightly greater in VOL2, although the difference was very small (1-2%).

### **Discussion**

The aim of this study was to investigate the effect on cow performance when cows were transitioned from a voluntary trafficking system to a semi-batch system and back to voluntary. The concern with such an approach related to whether or not the cow would resume voluntary cow traffic (without significant negative impacts on milking frequency and milk production) after a relatively prolonged period of semi-batch milking.

**Table 1. Predicted mean milking frequency (MF); milk yield per day (MYD); milk yield per visit (MYV); concentrate consumption (CC); percentage of concentrate consumed (%CC); incomplete milkings (INC)**

|                          | Traffic system     |                    |                    | SED  |
|--------------------------|--------------------|--------------------|--------------------|------|
|                          | VOL1               | SB                 | VOL2               |      |
| MF<br>(milkings/cow/day) | 2.14 <sup>b</sup>  | 1.97 <sup>c</sup>  | 2.31 <sup>a</sup>  | 0.04 |
| MYD<br>(kg/cow/day)      | 35.3 <sup>a</sup>  | 34.44 <sup>b</sup> | 35.5 <sup>a</sup>  | 0.3  |
| MYV<br>(kg/cow/visit)    | 16.51 <sup>b</sup> | 17.26 <sup>a</sup> | 15.57 <sup>c</sup> | 0.17 |
| CC (kgDM/day)            | 8.40 <sup>c</sup>  | 8.62 <sup>a</sup>  | 8.53 <sup>b</sup>  | 0.11 |
| % CC (%)                 | 95.14              | 95.59              | 96.06              | 0.3  |
| INC (%)                  | 5 <sup>b</sup>     | 3 <sup>c</sup>     | 9 <sup>a</sup>     | 0.01 |

SED: Standard error of the difference; Different letters (within row) indicate significant differences ( $P < 0.001$ ) between groups.

Milking frequency dropped from 2.14 milkings/cow/day to 1.97 milkings/cow/day when cows were shifted from VOL1 to SB system. This was expected as they were restricted to two defined milking session times. Interestingly, when the management strategy was reverted to VOL2 (after the 8 week period of semi-batching) the milking frequency increased to 2.30 milkings/cow/day, indicating that cows responded positively to the change of management. This increase in MF is particularly interesting given that the study cows were into mid-lactation as they moved into the VOL2 treatment. Two weeks prior to the end of SB, week 15, the spring herd started calving and fresh cows joined the autumn milking herd, this may well have impacted on the motivation levels of the autumn calvers being studied and likely provides at least partial explanation for the increase in MF. This would also have been the case if the autumn cows had been managed with voluntary cow traffic throughout the full 8 week winter period and it is possible that the autumn calvers would have responded with an increase in MF even earlier (as the spring calvers started joining the herd) if they had not been restricted with the SB strategy.

Daily milk yield decreased 0.86 litres/cow/day when cows were restricted to the SB milking strategy. This was likely due to the slight reduction in mean MF. However, because MF typically achieved in AMS pasture-based system are not typically much higher than 2 milkings/day (Lyons *et al.* 2013), the losses in milk production might be compensated by the long term benefits of eliminating milking intervals that extended beyond 16 hours. Further long term benefits might have been generated by the almost elimination of extended milkings (at a quarter level) resulting from incomplete milkings. Interestingly MYV was greater for the SB period, resulting in a higher milk harvesting efficiency, and was lower for the VOL2 period since the increase in milking frequency did not result in a proportionately higher MYV. Still, the increase in DMY achieved in VOL2 was encouraging, particularly in light of the fact that cows were beyond the first 100 days of lactation.

Although the level of incomplete milkings was acceptably low at the beginning of the study (5%), a significant decrease in the incidence of INC was reported during the SB period, as cups were manually attached to reduce milking session time. The incidence of incomplete milkings increased during the VOL2 period. The explanation for this is likely multi-factorial but could include the lower milk yield/milking, some disturbance created by the fresh spring calving cows and/or an increase in the variation of intervals between successive milkings.

Contrary to the expected, there was no significant difference between periods in the percentage of concentrate consumption (%CC), with defined milking sessions it was expected that a high number of cows could be present in the feeding area at the same time, creating an increased level of congestion and competition for the feeding stations. This does not appear to have been the case in this study and is likely to be directly related to the number of feeding stations available (20 parlours feeders) and the rate (cows/hour) of cows exiting the dairy. It is possible that the SB management strategy

resulted in cows accessing the feeding stations in more of a hierarchical order which may have reduced the likelihood that some cows were not able to access their concentrate allocation without being disturbed by more dominant herdmates. Concentrate consumption increased significantly (but only by 2.6%) when the study cows shifted to SB. This was somewhat surprising given the reduced visitation frequency and the reduced milk yield but it also could be explained by the increment in the allowance with stage of lactation.

## Conclusion

The findings presented in this study indicate that experienced cows can be transitioned from semi-batch milking and back to voluntary milking without significant negative impacts on cow performance. Semi-batch milking could be a feasible management option for pasture-based AMS to address periods of underutilization of the equipment.

## Acknowledgement

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# AN INVESTIGATION INTO THE PERFORMANCE AND EATING QUALITY OF HOLSTEIN STEERS

**Veronika Vivic**

V. Vivic<sup>AC</sup>, M.A. Campbell<sup>A</sup> and M.B. Allworth<sup>AB</sup>

<sup>A</sup>Charles Sturt University, Wagga Wagga, NSW 2678, Australia

<sup>B</sup>Graham Center for Agricultural Innovation (NSW Department of Primary Industries and Charles Sturt University) Locked Bag 588, Wagga Wagga, NSW 2678, Australia.

<sup>C</sup>Corresponding author. Email: veronikavivic1@gmail.com

## Abstract

*The Australian dairy industry encounters many publicised animal welfare concerns regarding the treatment and euthanasia of male calves. Consumer demand for beef is increasing worldwide. Developing a viable beef dairy chain in Australia based on objective data can address the welfare issues associated with male dairy calves. The aim of this project is to assess the carcass performance and eating quality of Holstein steers finished on a concentrate diet, compared to traditional British bred cattle. This trial has not yet reached completion therefore, this paper will be a review of current literature regarding the performance and eating quality of Holstein beef. Literature findings suggest that the meat quality from dairy breeds outperforms meat quality from traditional beef bred cattle due to increased marbling, which may be associated with improved eating quality. Currently, no similar trials have been performed in Australia which justifies the need to undertake this project and perform consumer trials to assess the marketability of Holstein beef.*

## Introduction

There are many publicised animal welfare concerns surrounding the Australian dairy industry. The majority of these topical issues are in regards to the treatment of male calves, particularly those euthanized at birth. The Australian dairy industry slaughters over 500,000 calves per year, which accounts for 6.8% of the beef industry on a per head basis. Commonly these calves are marketed as veal with carcasses that range between 50-150kg. However, veal carcasses are so light they only account for 1.3% of Australia's total meat production on a per kg basis each year (MLA, 2017, p. 3).

Australia has many export markets for beef and veal products. The largest importing countries of Australian beef and veal are the United States of America (US), Japan, Korea and China, followed by other nations (ABARES, 2016). Within these international markets, beef consumption is forecast to rise by 15% in next

10 years. The largest contributor to this rise is predicted to be China, one of Australia's largest importers (MLA, 2016).

The Australian beef cattle herd has declined in recent years (ABARES, 2016). This is not ideal considering the demand and trends surrounding beef consumption in domestic and international markets is proven to be rising (MLA, 2016).

## Literature Review Findings

The term bobby calf is widely accepted in Australia for male calves most commonly culled at less than 10 days of age from a dairy herd. These calves are regarded as a low value by-product of the dairy industry (Cave, Callinan, & Woonton, 2005).

Pre-slaughter transport is of most concern in regards to the welfare of bobby calves. There are many factors that can influence the physiological stress experienced by calves during transportation. These factors are

inclusive of age, stocking densities on trucks, transportation flooring and distance of transportation to an abattoir (Jongman & Butler, 2014). Through establishing a market for Holstein beef, the welfare issues associated with bobby calves can be eliminated.

Mulley, *et al* 2014 suggest that dairy influenced steers can produce equal or greater meat quality compared to traditional beef bred cattle. If producers are able to grow out bobby calves knowing they can achieve a high quality carcass and gain optimal prices for their product, this may provide some incentive to change current practices that occur within the dairy industry.

Commercial feedlot data recommends that Holstein steers consume a lower dry matter intake and can exceed the performance and grading of traditional beef breeds raised under similar conditions (Rust and Abney, 2005); however, the dressing percentage for Holstein cattle is generally lower than traditional beef breeds (Buege, 1988). The muscle shape of Holstein steers also varies from that of traditional beef breeds. This can be problematic for commercialised businesses in the hospitality sector that have specific criteria for cuts of meat (Buege, 1988).

In America, Holstein steers account for a significant proportion of the national US beef supply, generally the meat is used in ground beef products (NASS, 2005). It is common practice for Holstein calves to be placed in calf rearing facilities and fed concentrate feedstuffs for the duration of production (Keane & Allen, 2002). Due to pasture availability in Australia it would be ideal to evaluate the performance of Holstein cattle grown on pasture and provide an energy dense diet as a finishing process. Keane & Allen (2002) found that feeding Holsteins high concentrate diets compare to low concentrate diets did not influence change to any carcass traits however, high concentrate diets improved carcass weight and conformation. This suggest that growing Holstein steers on a low energy diet may be a viable option for producers to follow. It would increase the economic viability of raising Holstein calves in Australia and make it easier for produces to integrate this practice into their current farming systems.

There is limited information in regards to the eating quality of Holstein beef but it is common across literature that it has higher accounts of

marbling. Armbruster *et. Al.* (1983) concluded in their eating quality trail that higher levels of marbling was associated with an increase in tenderness. This could be of preferable to consumers and a good way to market Holstein beef products. Other qualities that influence the overall taste of Holstein beef need to be assessed in more depth, this could also allow producers to gain more knowledge about their product.

Due to the lack of information surrounding consumer opinion and preference on Holstein beef, the production of dairy beef needs to be further investigated to evaluate the potential of a viable dairy beef chain within Australia. This trial will provide comparative baseline data for the production of Holstein cattle verse British bred cattle finished on a common diet.

### **Research objectives**

The research objective for this experiment is to evaluate the performance and eating quality of Holstein verse British bred steers, finished on a common diet. Through this experimentation it can be determined which breed of cattle produces superior eating quality.

If the consumer sensory trials show that there is a preference for meat produced by Holstein steers, this could be an opportunity for Australian dairy farmers to expand and integrate their enterprise into the beef market.

As this is a pilot study, this project can provide data for a larger project investigating the establishment of a viable beef dairy chain and in turn address the welfare of bobby calves.

### **Materials and Methods**

15 Holstein steers and 15 British steers are being used to conduct this pilot trial. These steers are being managed on a local farm located in Wagga Wagga. They have been placed in a paddock with limited pasture availability and are fed a variable mixed ration on a weekly basis. The concentrate feed was initially available to steers in May 2017 and will be fed until slaughter in August 2017. All the steers will be processed at Tey's Australia in Wagga Wagga. Tey's will provide MSA reports and AUS-MEAT data associated with each steer; this is inclusive of meat and fat colour, pH, intramuscular fat (IMF), eye muscle area, rib fat, as well as the dressing

percentages of each carcass. Measurements will be graded by trained personnel according to the Meat Standards Australia (MSA) protocols. The carcass data provided by Tey's will be used to make a comparative analysis of the performance of Holstein and British bred steers finished on a common diet.

Striploins from each carcass will be collected and tenderness will be measured using Warner-Bratzler shear force instrument.

The striploins will also be utilised to perform consumer sensory trials. For sensory evaluation, 100 random untrained consumers will be recruited to evaluate the tenderness, juiciness and flavor of meat according to the MSA sensory testing protocols described by Watson *et al.* (2008). 10 portions of steak will be available from each muscle. Consumers will receive four portions of steak; two from Holstein carcasses and two from a British bred carcass. These steaks will be distributed blindly so there is no bias formulated around scoring.

Consumer scores will then be evaluated to establish how Holstein beef performs compared to traditional British bred beef.

## Discussion

As previously mentioned there are limited comparative studies that have been performed regarding the performance and quality of Holstein beef. It would be ideal to establish an industry benchmark in regards to performance of Holstein beef compared to traditional beef bred cattle. This will allow both the beef and dairy industry to find an output for the surplus of bobby calves. Through establishing a viable dairy beef chain we can add value to a product that is economically regarded as low value in the supply chain. If this pilot study as well as further studies conclude Holstein cattle perform just as well as traditional beef bred cattle, producers may like to consider and can work towards a dual purpose animal in their herds. This can be done by selecting for premium meat quality traits as well as maintain high milk production in their dairy herds.

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# EVOLUTION OF DAIRY CATTLE AND FARMER BEHAVIOUR AFTER TRANSITIONING FROM CONVENTIONAL TO AUTOMATIC MILKING SYSTEMS.

**A.M. Wildridge<sup>AD</sup>, P.C Thomson<sup>B</sup>, S.C Garcia<sup>A</sup>, E.C. Jongman<sup>C</sup>, C.E.F. Clark<sup>A</sup> and K.L. Kerrisk<sup>A</sup>.**

<sup>A</sup>*Dairy Science Group, School of Life and Environmental Science, Faculty of Science, The University of Sydney, Camden, NSW, 2570.*

<sup>B</sup>*School of Life and Environmental Science, Faculty of Science, The University of Sydney, Camden, NSW, 2570.*

<sup>C</sup>*Animal Welfare Science Centre, Faculty of Veterinary and Agricultural Sciences, The University of Melbourne, Parkville, Vic., 3010.*

<sup>D</sup>*Corresponding author. Email: ashleigh.wildridge@sydney.edu.au*

## Abstract

Anecdotal evidence suggests that both farmer and cattle behaviour change when a farm transitions from a conventional milking system (CMS) to an automatic milking systems (AMS). Here we show the level and nature of farmer-cattle interactions from five CMS that were audited over a six day period before they transitioned to an AMS, and again 12 months later. Farmer routine, cattle avoidance distances and farmer-cattle interactions were recorded during these observations. Four farmers spent less total time interacting with their cattle each day in the AMS, but spent more time performing tasks near the cattle ( $P < 0.01$ ) and working with cattle in small yards or restraint facilities ( $P = 0.04$ ) as compared to the CMS. Cattle avoidance distance was shorter ( $P < 0.01$ ) after transitioning to an AMS. The number of verbal encouragements used by farmers to encourage cattle to move through a gate during a handling exercise was greater after transition to an AMS ( $P < 0.01$ ), however, cattle responded with reduced reactivity as seen by reduced 'running past the farmer' ( $P < 0.01$ ) and less slipping ( $P < 0.01$ ) when being encouraged by the farmer. These findings indicate that cattle are less fearful towards humans in an AMS compared to a CMS and that this may be associated with the changes identified in daily farmer routine.

## Introduction

Since the establishment of the first automatic milking systems (AMS) in 1992 (de Koning and Rodenburg 2004), a substantial amount of research has been conducted to evaluate the social and on-farm benefits of AMS (Mathijs 2004). The impact of milking system has been evaluated from cattle stress responses, health parameters and behavioural indicators. Cattle stress as measured by cortisol levels has been variable for both conventional milking systems (CMS) and AMS with the predominant finding indicating no difference (Gygax et al. 2006).

Similarly, health parameters and behavioural indicators such as lameness (de Koning 2010), body condition (Dearing et al. 2004), udder health (Svennersten-Sjaunja and Pettersson 2008) and stepping during milking (Hagen et al. 2004) were not consistently different between the two systems. However, this research is confounded by factors such as management, farmer personality and staff attitudes (among other things) as differing AMS and CMS farms were compared, not the transition of the same farms.

Our objective was to determine the changing level and nature of farmer-cattle interactions on farms transitioning to AMS (from CMS), in an attempt to quantify anecdotal evidence that cattle are quieter in an AMS compared to a CMS.

## Methods

### Design

Five farms in New South Wales, Victoria and Tasmania (Australia) transitioning from a CMS to an AMS participated in the study during 2015 and 2016. The farms milked between 280 and 540 cattle on four pasture-based systems and one indoor system with either herringbone or rotary milking parlours. After conversion to AMS, four farms milked in multiple single box AMS and one farm utilised an automatic milking rotary (AMR™, DeLaval, Tumba, Sweden).

Each of the farms was visited once within 6 months before AMS transition, and again one year later ( $\pm 9$  days). During the farm visits, farmers were 'observed' (where the observer neither intervened nor interfered with any activity) for three days to record interactions between farmers and lactating cattle, followed by an assessment of the avoidance (flight) distance of a selection of focal cattle within the herd and a handling test with the same selection of cattle.

The focal cattle were selected as a representative group of the milking herd with a variety of ages, days in milk (DIM) and daily milk yields (MY). Approximately 70 focal cattle were selected based on sample size figures reported by Hoffman *et al.* (2012).

Avoidance distance was recorded by a laser distance recorder (Ryobi, Australia) as the observer walked in a standardised manner towards the shoulder of each focal cow in the paddock (or indoor facility). Prior to the handling test, the focal cattle were drafted or moved (depending upon facilities) into a holding yard. The handling test involved the farmer moving each cow individually through a gate into another yard.

All physical contact (e.g. patting or slapping) and verbal encouragement (e.g. talking or whistling) by the farmer were recorded, as was

the behaviour (walk, run, slip) of each cow as it passed through the gate.

### Statistical analysis

Daily farmer-cattle interactions were categorised into five tasks: milk (milk harvesting tasks), fetch (actively encouraging cattle movement), feed (distributing feed in the presence of cattle), near (tasks in close visual proximity to cattle but not interacting directly with them, excludes milk harvesting, fetching and feeding) and contact (physical contact with cattle in confined areas excluding milk harvesting, fetching and feeding, e.g. artificial insemination, hoof trimming).

Time spent on each task was analysed for the CMS and the AMS with a linear mixed model (fitted using a REML procedure) in GenStat® 16th edition (VSN International, Hemel Hempstead, UK) to determine if time spent on each task was linked to milking system. Time spent on each activity was transformed ( $\log_e[\text{minutes} + 1]$ ) to improve data normality and variance stability.

Cattle behaviour was examined using two models, the first looking at associations of avoidance distance in meters ( $\log_e[\text{distance} + 1]$ ) with dairy type (CMS, AMS), cattle age and DIM using another mixed model. The second model was a generalised linear model fitted to data from the handling exercise to determine the probability of each farmer or cattle behaviour occurring in each of the dairy types (CMS or AMS).

## Results

Four farms spent less total time on tasks involving farmer-cattle interactions after AMS transition predominately due to milk harvesting-related tasks being almost eliminated with AMS. The indoor farm was the only farm to increase interaction time.

**Table 1: Predicted mean time (minutes/day) spent interacting with cattle in the conventional milking system (CMS) and in the automatic milking system (AMS) for each task (feed, fetch, milk, near and contact).**

|                | CMS   | AMS  | P value | SED* |
|----------------|-------|------|---------|------|
| <b>Feed</b>    | 6.3   | 3.4  | 0.48    | 0.92 |
| <b>Fetch</b>   | 82.5  | 73.8 | 0.60    | 0.21 |
| <b>Milk</b>    | 245.7 | 1.2  | <0.01   | 1.23 |
| <b>Near</b>    | 0.0   | 59.8 | <0.01   | 0.56 |
| <b>Contact</b> | 3.3   | 17.6 | 0.03    | 0.56 |

\*SED = standard error of difference of means

Changes in avoidance distance were associated with milking facility (CMS and AMS,  $P < 0.01$ ) and cattle age ( $P < 0.01$ ), but not with cattle DIM ( $P = 0.47$ ). The predicted mean avoidance distance of CMS cattle (3.27 m) was 37% further than the avoidance distance of AMS cattle (2.39 m). Predicted means for cattle age indicated that older cattle had a shorter avoidance distance than younger cattle.

After transition to AMS, cattle were significantly less likely to run or slip, and more likely to walk when they were subjected to the handling test. Whilst there was no change in the frequency of physical contact, AMS farmers were more likely to use verbal encouragement during the handling test (Table 2).

## Discussion

Previous research has proposed that increasing the use of labour-saving technologies that reduce human contact with cattle, will increase human association with negative interactions leading to an increase in cattle fear responses (Rushen *et al.* 1999). However in the current study reduced human interaction with increased mechanisation led to an improved farmer-cattle relationship indicating that farmer interactions with the cattle in the AMS were considered to be more positive by the cattle.

**Table 2: Predicted proportion of cattle handled where verbal or physical effort was used by the farmers and the proportion of cattle responding by walking (walk), running (run) and/or slipping (slip) in conventional milking systems (CMS) and automatic milking systems (AMS).**

|                 | Milking system |      |         |      |
|-----------------|----------------|------|---------|------|
|                 | CMS            | AMS  | P value | SE*  |
| <b>Verbal</b>   | 0.08           | 0.15 | <0.01   | 0.02 |
| <b>Physical</b> | 0.09           | 0.06 | 0.27    | 0.01 |
| <b>Walk</b>     | 0.47           | 0.73 | < 0.01  | 0.03 |
| <b>Run</b>      | 0.50           | 0.29 | < 0.01  | 0.03 |
| <b>Slip</b>     | 0.09           | 0.01 | < 0.01  | 0.01 |

\*SE = standard error

When farmers were managing their herds in the AMS, they decreased the total average time spent interacting with cattle each day from 5.6 h in the CMS, to 2.6 h in the AMS which is in agreement with findings reported by Molfino *et al.* (2012). This was due to milk harvesting tasks being almost eliminated and an increase (albeit small in magnitude) in tasks related to being 'near' or in 'contact' with the cattle. Time spent 'near' cattle was not seen in the CMS as when farmers were near the cattle, it was due to 'milk', 'fetch', 'feed' or 'contact'. With 24 h milking in the AMS, farmers were often near cattle (generally in small groups and rarely whole herd) when performing tasks such as cleaning or moving fences, in addition, some farms were undertaking construction leading to more time spent 'near' the cattle than might otherwise be expected. The exception to this was the indoor milking system, where interactions increased in the AMS due to a strong objective to increase system and cattle productivity through regular fetching and monitoring. As heart rate is generally greater during milking than resting or feeding (Gygax *et al.* 2008), the removal of human association with milk harvesting (and related interactions) is proposed to be linked to the reduction in avoidance distance of cattle to an unknown

person. With the avoidance distance of cattle being a good reflection of the human-animal relationship (Waiblinger *et al.* 2003), this reduction is thought to indicate that the changes to farmer routine identified in the AMS had been positive.

The results of the handling test further supported an improvement to the farmer-cattle relationship as measured by the occurrence of observed running events when farmers move in close proximity to the cattle (Grandin 1980). A significant reduction in running and slipping suggests that the cattle were less stressed when the farmers moved close towards them and separated them from the group to encourage them through the gate. Farmer verbal encouragements were greater after transition to an AMS, which may further suggest that the cows were less fearful and that the farmers were required to exert more effort to encourage the cattle to move.

## Conclusion

The reduction in fear responses of cattle to both handling and approach from an unfamiliar person in the AMS indicates that the anecdotal statement that cattle appear to be quieter in an AMS is true. This change in cattle behaviour is thought to be linked to the change in the farmer-cattle interactions of farms transitioning to AMS from a CMS.

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# WATER AUDITING: THE FIRST STEP TO EFFECTIVE EFFLUENT MANAGEMENT ON DAIRY FARMS IN SOUTH WEST WESTERN AUSTRALIA

**Senge, L.**

*Murdoch University*

## **Abstract**

*This project investigates the possibility of achieving zero waste discharge on a dairy farm in south west Western Australia. The current best practices for dairy farm effluent treatment were assessed in a literature review, a water audit and a nutrient balance were conducted on a specific farm in Boyanup, W. A. with 500 cattle. The findings were 52 kL of freshwater usage per day, higher than industry benchmarks. Nutrients were leaking into groundwater table at six meters depth at low concentrations.*

*Four different options were assessed in a techno-economic options assessment. These options consisted of no action to be taken, installing a pond for effluent storage, installing a tank for effluent storage, and recycling effluent after primary treatment for dairy yard wash with construction of a roof on the yard for additional rainwater catchment and reduction of heat stress on cows. The paper concludes in the recommendation of a hybrid option incorporating effluent recycling for yard wash by installation of flood wash tanks, construction of a pond for storage during wet seasons and the erection of a roof on the yard for additional rainwater catchment and reduction of heat stress on cows.*

*This final recommendation was designed to achieve zero waste discharge and showed further benefits such as an increase in milk production and a reduction of labour. The installation cost for the proposed overall system was estimated at \$170,000 with a payback period of 6.2 years.*

## **Introduction**

Dairy farm effluent and the nutrients it carries can have a significant environmental impact on waterways. Over the past 50 years, the dairy industry has experienced a reduction in the number of farms whilst the number of cattle per farm has increased, leading to centralisation and intensification of potential environmental pollution (Agriculture and Resource Management Council of Australia and New Zealand; Australian and New Zealand Environment and Conservation Council 1999).

Effluent from cowshed wash down is rich in manure, and consequently nutrients often filter directly to farm paddocks and creeks, exceeding the nutrient assimilation rate of soils and thereby contributing to eutrophication in nearby waterways (GeoCatch 2017).

## **Objectives**

This project is aimed at using water auditing in combination with a nutrient balance on a farm in south west Western Australia to propose a system design achieving zero waste discharge (ZWD). Major goals were estimating budget of the different options and a final payback period.

## **Site Description**

The Peninsula Downs Dardanup farm, Twomey's farm, is located at 127 Collins Rd, Boyanup, WA 6237, 200 km south of Perth and 20 km south-east of Bunbury and houses 500 cows.

## Soils and groundwater hydrology

The farm is situated within the Swan Coastal Plain, with the farm located at about 40m elevation.

The superficial formation mainly consists of Bassendean Sand and Guildford Clay. This deposit is usually found at a depth of 6 m to 30 m, with the superficial aquifer at a depth of 6 – 10 m.

Below the superficial formation is the Leederville formation with a thickness of about 200 m, beneath the Leederville aquifer representing a thickness of about 300 m (Milligan 2016).

The third formation is the Yarragadee formation which is about 500 m thick, terminated at the lower end by the Bunbury Basalt (Baddock 2005). The Yarragadee aquifer is likely to be found at 40 m below ground level (Milligan 2016).

## Rainfall, Climate and surface water

The hot and dry summers show temperatures of 14 – 40°C, whilst the wet and cold winters are between 5 and 26 °C. Ninety per cent of the rainfall occurs during winter, mainly between May and September (Weatherzone 2017).

Annual rainfall for 2016 – 2017 was 840.8 mm, slightly above the annual average of 772.2 mm from 2004 – 2016 (Bureau of Meteorology 2017).

The dairy is in the Leschenault Catchment, starting at the Darling Plateau and draining into the Leschanault Estuary (Department of Water 2012).

## Water Audit

The water audit was conducted from Saturday 13 May 2017, 5:30 am till Sunday 14 May 2017 till 10:30 am.

## Freshwater

Fresh water for the farm is supplied by a superficial bore (dam) and a Leederville bore, with a combined licence of 527,490 kL annually. It is pumped to a 130,000 L tank adjacent to the dairy shed for daily use.

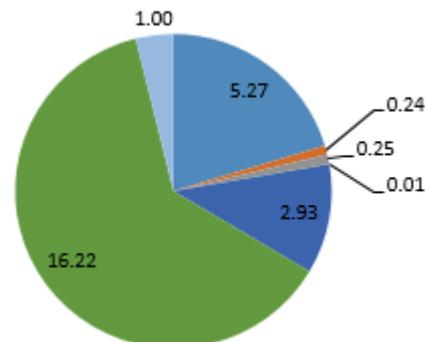
## Rainwater

Rainwater is currently collected from the dairy shed roof, resulting in annual catchments of 350 kL when applying a runoff coefficient of 0.9, and stored in a tank, contributing to the fresh water supply. The catchment of the yard is 620 kL annually and the catchment of the trafficable solids trap (TST) 60 kL, both contributing to the effluent stream.

## Water usage inside the dairy

All water used in the dairy and the yard is channeled into a TST with a T-piece and then directly applied to the paddock, via pump and pivot irrigator. This process occurs twice per day.

The audit was carried out with a combination of meter installation where possible and bucket and stopwatch method where not possible. Obtained data can be found in Figure 1 below.



**Figure 1: Water usage breakdown in kiloliters by outlet for one milking cycle**

It was found that the largest water consumption occurred at the hydrants used for yard wash down, as with an average use per milking cycle of 16.22 kL they represented 63% of the water usage. The second largest usage was observed at the entry spray, with 5.27 kL. The third largest usage (2.93 kL) were the white wash down hoses, used inside the shed after each milking cycle. The vat wash contributed with 1.00 kL. Negligible was the usage of the green hoses at a combined volume of 0.5 kL, or 2% of the total water usage. The total average water usage per milking cycle is 26 kL. At the current herd size of 500 cattle the water usage per cow is 52 L/cow/milking.

## Irrigation

Irrigation was not included in the water audit, but was reported to be the largest fresh water consumption over the whole farm. In the previous year, it was only irrigated from January till April, with a total consumption of 143,790 kL, using 42.4% of the license, whilst the volume used on the whole farm that year was 339,515 kL.

## Leakage

Conducted leakage tests inside the dairy have not shown any leakage, however leakage was visually observed at the pivot after each application, at a rate of 2.5 L/min for an unknown duration.

## Closure

The total water input observed for one milking cycle was calculated by tank level drop. A reduction in water level height of 450 mm equaled a volume of 27 kL being used out of the tank. The total volume used for this milking cycle was 25.6 kL.

$$Closure = \frac{27,000L - 25,600L}{27,000L} * 100\% = \underline{\underline{5.2\%}}$$

A closure of 5.2 % is very accurate considering the equipment available. However, it would be recommended to rely on further meter installation in the future than to use estimations such as tank level drops and reliance on one person timing the usage of each outlet for the duration of the audit.

## Nutrient balance

### Sampling

Sample 1 was collected at the channel from the yard into the TST. This sample will represent the raw input to the process.

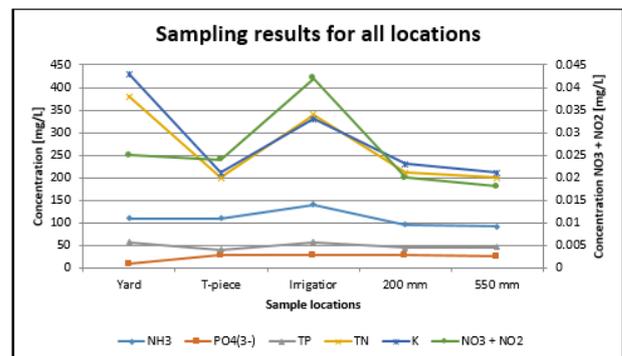
Sample 2 was taken at the outlet of the T-piece and shows treatment by the TST, before the effluent is pumped to the irrigator.

Sample 3 was taken by placing containers on the paddock and collecting irrigation water. This sample is expected to show very similar levels to Sample 2.

Sample 4 was taken with a lysimeter after penetration through 200 mm of soil. This sample should have experienced nutrient uptake by plants and soil, and therefore contain less nutrients than previous samples.

Sample 5 was taken with a lysimeter after penetration through 550 mm of soil. This sample should show the lowest levels of nutrient contents.

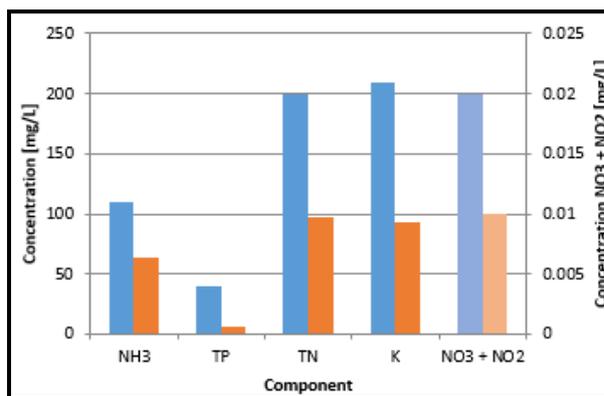
All samples were tested for NH<sub>3</sub>, PO<sub>4</sub><sup>3-</sup>, NO<sub>3</sub> and NO<sub>2</sub>, TP, TN and K and results plotted in Figure 2 below.



**Figure 2: Sampling results for all locations**

The decrease in concentrations from yard to T-piece was expected, as primary treatment occurred in the TST. However, the increase from T piece to irrigator was not expected. Part of the explanation would be that the discharge water from vat wash was injected into the TST just before the T-piece, diluting that sample and resulting in extreme low concentrations. However, that still does not explain why some samples show a higher concentration at the irrigator than the yard. The samples taken after the irrigator in the soil show the expected decrease in concentration due to plant and soil uptake.

The T-piece samples were taken on two occasions, showing a significant difference in concentration, shown in Figure 3 below.



**Figure 3: Comparison T-piece samples**

The first sample was taken as soon as the TST was overflowing through the T-piece, whilst the second sample was taken at the very end of the milking cycle, when the vat wash was ongoing.

#### Nutrient transportation after irrigation

The uptake in between the lysimeter at a depth of 200 mm and 550 mm was due to soil uptake, whilst above 200 mm plant uptake needed to be considered.

Therefore, an extrapolation of the uptake of nutrients over these 350 mm has been performed to the depth of the groundwater table (6m). It was found that:

- TP could not be extrapolated as its concentration increased,
- K and  $PO_4^{3-}$  were taken up above groundwater table,
- $NH_3$  reached the groundwater with a concentration of 22 mg/L,
- TN reached the groundwater with a concentration of 28 mg/L,
- $NO_3$  &  $NO_2$  reached the groundwater with a concentration of 0.007 mg/L.

#### Techno-economic options assessment

Several approaches and technologies were investigated to achieve ZWD for Twomey's farm whilst not affecting the milking process and the ongoing economics of the corporation. These options were assessed and the most

viable option presented as the final recommendation.

The options assessed were:

1. No action
2. Single pond for storage
3. Tank for storage
4. Floodwash tanks for yard wash plus roof on yard for rainwater collection.

Option 2 was ruled out first, as the installation cost of a tank with a total capacity of the required 11.34 ML (S. Birchall, Effluent Toolkit ver\_11\_6 2016) was estimated in the millions.

Option 1 was also ruled out, as it did not achieve ZWD and the environmental risk was rather high.

Option 4 was by far the most preferable option, as it decreased the effluent volume significantly as well as the freshwater usage, increased productivity and reduced labour requirement.

#### The final design

The final design was a hybrid of options 4 and 2, a roof and a floodwash system for the yard with a single pond for storage during wet season. In addition, a second pivot was suggested to be connected for effluent distribution, to allow for sufficient application area.

Due to the floodwash system the pond size required was reduced to a total capacity of 8.7 ML, estimated at \$42,000 maximum, including survey and geotechnical investigations. Estimated costs for the final system can be found in Table 1 below.

#### Payback period

The payback period was estimated to be 6.2 years. Major factors were the estimated increased production due to heat stress avoided by installation of the roof at \$22,500 annually and \$4,800 of labour cost savings due to the floodwash system. Electricity savings due to less pumping were estimated at \$400 per year and therefore neglected. If water

was not free of charge, the payback period would shorten drastically.

**Table: Final cost summary**

| Item                                    | Cost              |
|---|-------------------|
| Yard roof                               | \$ 60,000         |
| Flood wash tanks                        | \$ 18,000         |
| Pond                                    | \$ 42,000         |
| New pipe work                           | \$ 10,000         |
| Connection of second pivot for effluent | \$ 10,000         |
| Contingency (20%)                       | \$ 28,000         |
| <b>Total</b>                            | <b>\$ 168,000</b> |

The total estimated cost for the designed ZWD system was \$168,000.

## Conclusion

The desired goal of achieving a zero waste discharge on a dairy farm was found to be possible.

The planned improvements to the site included an additional rain water catchment area resulting in a reduction of fresh water use. Although the cost of fresh water was not an issue for Twomey's farm, the lower volume of fresh water being used meant a reduction of contribution to the effluent stream. The same component would reduce heat stress on the cows and thereby increase the volume of production at the farm. If followed, the suggested solution of recycling wastewater after primary treatment would reduce labour costs and effluent discharge to the paddock, therefore providing a reduction of the size of the effluent application area necessary.

With a total cost estimated at \$168,000 and a payback period at 6.2 years, the system proposed was found to be a viable option.

In conclusion, it is recommended to employ the benefit of zero waste discharge systems. For future projects, it is recommended to extend audit and sampling periods over a year if possible, to allow for consideration of dry and wet seasons and larger sampling ranges.

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# URINATION BEHAVIOUR, URINARY NITROGEN COMPOSITION AND URINARY VOLUME OF DAIRY HEIFERS GRAZING PERENNIAL PASTURE, WHEAT AND CANOLA

**Long Cheng, J. McCormick, L. Guinot, A.N. Hussein, C. Logan and G.R. Edwards**

*Faculty of Veterinary and Agricultural Sciences, Dookie Campus, Victoria 3647, The University of Melbourne, Australia*

*School of Agriculture and Wine Sciences, Charles Sturt University, Australia*

*Paris Institute of Technology for Life, Food and Environmental Sciences, AgroParisTech, France*

*Faculty of Agriculture and Life Sciences, Lincoln University, PO Box 85084, New Zealand*

*Corresponding author [long.cheng@unimelb.edu.au](mailto:long.cheng@unimelb.edu.au)*

## Abstract

*This study examined urination behaviour, urinary nitrogen composition and urinary volume of dairy heifers grazing perennial pasture, wheat and canola. A total of 24 Friesian x Jersey heifers, aged 11 months old were allocated into three treatment groups: canola, wheat or pasture. Heifers offered canola urinated 1.5 times more frequently than those had wheat and pasture ( $P < 0.05$ ). The urination duration was 20% lower in pasture group than other two groups ( $P < 0.05$ ). Heifers offered pasture tended to have higher urinary urea concentration than other two groups ( $P = 0.072$ ). Urinary hippuric acid concentration was lower in canola than other two groups ( $P < 0.05$ ). The overall result suggests that grazing canola and wheat compared with pasture may provide opportunity to reduce nitrogen losses to the environment.*

## Introduction

Previous work showed that grazing canola and wheat compared with perennial pasture may improve heifers liveweight gain (LWG), and also potentially reduce nitrogen (N) losses to the environment by reducing the daily N excretion in the urine (Cheng *et al.*, 2016). However, under the grazing system in New Zealand, urine patch size and N composition, particularly urea concentration, are the major factors contributing to the N leaching in the soil (Selbie *et al.*, 2015), and nitrous oxide emission (Dijkstra *et al.*, 2013). To the best of our knowledge, there is limited published data available on urination behaviour together with urinary N composition measurement of dairy heifers grazing pasture versus canola and wheat. Therefore, the objective of this study was to investigate urination behaviour, urinary N composition and urinary volume of dairy

heifers grazing perennial pasture, wheat and canola in winter.

## Materials and Methods

This study comprised a 7-d feed adaptation period and a 26-d measurement period. 24 Friesian x Jersey heifers aged 11 months were blocked for their liveweight ( $223 \pm 10.3$  kg; mean  $\pm$  s.d.) and breeding worth (NZ\$ 143  $\pm$  17.9; mean  $\pm$  s.d.) into three dietary treatment groups: canola, wheat or pasture. Same feed allowance was offered every 4 days. On day 6 and 14 of the measurement period, urination behaviour was recorded during the first six hours of feed allocation according to the description of Cheng *et al.* (2015). Each occurrence and the duration of urination per heifer were also recorded. One urine sample was collected per heifer on day 12 and 18 of the measurement period, and analysed for N

composition. Data were analysed by ANOVA using Genstat (version 15.1), with forage type as treatment and individual animal as replicate.

## Results

Heifers offered canola urinated more frequently than those had wheat and pasture. The urination duration was lower in pasture group than other groups. Heifers offered pasture tended to have higher urinary urea concentration than other two groups. Urinary hippuric acid concentration was lower in canola than other two groups.

**Table 1: Urination behaviour, urinary nitrogen composition and urinary volume of dairy heifers grazing canola, pasture or wheat.**

|   | Canola            | Pasture           | Wheat             | LSD   | P-value |
|---|-------------------|-------------------|-------------------|-------|---------|
| Urination frequency (times/6 hours)       | 5.1 <sup>a</sup>  | 3.6 <sup>b</sup>  | 3.2 <sup>b</sup>  | 1.11  | 0.004   |
| Urination duration (mins/6 hours)         | 23.8 <sup>a</sup> | 19.8 <sup>b</sup> | 23.9 <sup>a</sup> | 2.37  | 0.002   |
| Urinary N concentration (%)               | 0.29              | 0.53              | 0.37              | 0.23  | 0.109   |
| Urinary urea concentration (g/L)          | 68.9              | 133.2             | 80.4              | 58.28 | 0.072   |
| Urinary creatinine (g/L)                  | 1.7               | 2.2               | 1.6               | 0.99  | 0.356   |
| Urinary hippuric acid concentration (g/L) | 6.5 <sup>b</sup>  | 17.0 <sup>a</sup> | 16.1 <sup>a</sup> | 6.72  | 0.006   |
| Estimated urinary volume (L/day)          | 53.6              | 33.3              | 51.6              | 36.07 | 0.450   |

## Discussion

Urea is a major N component in the urine. The lower urinary concentration observed in canola and wheat may provide opportunity to reduce N leaching in the soil and nitrous oxide (Dijkstra *et al.*, 2013). However, the benefit of reducing urinary urea concentration in canola compared with pasture may be partially offset by the lower urinary hippuric acid concentration, as Van Groeningen *et al.* (2006) suggested that higher hippuric acid concentration in the urine may lead to a reduction in nitrous oxide emission. The higher urinary frequency in

canola than pasture represents an opportunity to increase the spread of urine patches and N loading in soil and contribute to the reduction of N leaching (Williams and Haynes, 1994). Urinary duration can be used to reflect the volume of each urination event. The longer urination duration in canola and wheat than pasture may be explained by the numerically higher urinary volume observed in this study. Previous study indicated that higher urinary volume can dilute urinary urea concentration, and lead to a reduction in N leaching in soil, as well as nitrous oxide emission (Dijkstra *et al.*, 2013).

## Conclusions

This study demonstrated the potential use wheat and canola to reduce N leaching in the soil and nitrous oxide emission compared with pasture, through reducing urinary urea concentration and increasing urinary frequency and urinary duration. More work is needed to understand the reasons of the modification of the urination behaviour in wheat and canola.

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