THE DAIRY RESEARCH FOUNDATION'S

2013 SYMPOSIUM

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CURRENT TOPICS IN DAIRY PRODUCTION

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WELCOME TO THE DAIRY RESEARCH FOUNDATION 2013 SYMPOSIUM

It is with pleasure that we present to the Australian dairy industry, our new-look 2013 Dairy Research Foundation Symposium. After many years on Campus at Camden, we have welcomed the opportunity to take to the road in order to reach into other dairying regions and at the same time, visit two very different dairying businesses – each with much to offer the Symposium delegate.

As a consequence, the NSW dairy industry and beyond will gather at one of the most picturesque dairying regions of the state – as we centre our discussions around Kiama.

The 2013 Symposium has adopted the theme "Taking Control" – a very topical theme that is upper most in the minds of many business operators seeking to grow margins in tight times. To address this we have brought together a remarkable gathering of experts from both within and outside our sector.

The opening session is designed to be challenging as we draw on the experiences of the oil and gas sector to learn how it is this industry has the capacity to have greater influence over its end game; and then we turn to a specific dairy example out of the Northern Hemisphere, as UK-based Nuffield Scholar and dairy farmer Joe Delves provides us an example of a UK dairy farmer negotiations on milk price.

But it's not all about milk price of course – and in true Symposium form we turn to science to help provide us the technical support in order to take greater control of our herd health and management outcomes and finally, to the social science aspect with business consultant Greg Mills.

This proceedings contains papers relating to all of our presentations on Day 1 and form an excellent reference source for you.

The second day of our program is on-farm and also contains the now highly-anticipated presentations from the nine finalists in the Emerging Scientists' Program. These young, passionate emerging dairy scientists have been chosen on the strength of their abstracts submitted and their papers in these proceedings will be formally assessed as part of the competition. Each finalist will present on farm and we will ask you, the audience, to judge their presentation and content to identify an overall winner.

I recommend the 2013 Dairy Research Foundation program to you and in particular, these proceedings which is a great testimony to the calibre of people presenting at this conference.

Assoc Professor Kendra Kerrisk

Programming Committee Chair,

Dairy Research Foundation Symposium 2013

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THE EMERGING DAIRY SCIENTISTS' PROGRAM

The DRF is pleased to showcase the talents of 9 emerging dairy scientists at the 2013 event. These presentations have been integrated into our Day 2 program and all have been paired with a senior consultant or scientist to create a highly interactive series of discussions.

The objective of this process is to offer a quality professional development opportunity for these emerging scientists and to introduce them to and integrate 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 – announced at the conclusion of Day 2.

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 science.

DAIRY RESEARCH FOUNDATION 2013
SYMPOSIUM SPONSORS

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

PLATINUM

GOLD

SILVER

BRONZE

CONTENTS

Reshaping attitudes to gain greater dairy influence

J. Delves

East Sussex, England

- As a child, my image of farming was long hours, an old truck and smelling of cows all day long. How do you view yourself?
- Don't be afraid to try things – if they don't work out then go back to what you were doing before.
- A ship without a rudder is going nowhere – get yourself a rudder.
- Don't focus on the things you can't control. In times of difficulty, the positive farmers are the long term players that aren't focusing on the issues right in front of them.
- Define what you love about being a farmer. Communicate them to everyone so that they realize that farming is a fantastic career choice that is open to anyone.

A wise man once said ''success is in the mind'' and when it comes to dairy farmers and their approach to business nothing could be more true.

My name is Joe Delves; I'm a dairy farmer's son from East Sussex in England. We are currently milking 220 cows (UK average herd 100) on an autumn block calving system. When I came into the business in 2005 things were a mess. Years of under investment and a lack of interest from the partners had taken its toll. The 120 milking cows were struggling to make a profit and the poor infrastructure of the farm meant that staff levels were high and the cows lacked the comfortable housing they deserve. Today the farm is very different, the cows have up to date facilities and the staff have a good working environment. Our profitability no longer depends solely on milk price or output. We have herbal rich pastures for the cows to graze during the spring, summer and autumn as well as deep sand bedded stalls for the winter.

My journey into dairy farming started when I left school and went to work on a neighbour's sheep farm. I hated working with sheep and was offered a job in construction after a few years of sheep farming. Construction was then a lot like your mining industry is today. High wages and an improved lifestyle were the main attraction for me. After a number of years working for someone, me and a friend decided to have a go on our own. We started up our own company and started to get some small projects. We went on to win some larger contracts and got to the point where we would have multiple sites running with no end of problems and people on each one. When my Father asked if I would be interested in coming home and buying into the farm I didn't think about it for even a minute, believe it or not being a dairy farmer is one of the best jobs in the world. This may sound strange but years of my phone ringing nonstop; having the constant headaches about cash flow due to late payments for work had ground me down. I needed to get back farming.

My aim today is challenge you about the way you view your business and yourselves. Coming from an industry that was tough and at times marginal, I approached farming with the same attitude as I did when I was building; I also believe that farmers should be at the front end of driving their industry forward. For years we have sat back and waited for government policy or supermarket power to steer our destiny, when we could of lead these discussions and stood up for ourselves. As farmers we are responsible for one of the key things needed for life "food", when we start to take ourselves seriously, people will take us more seriously. I have recently completed a 3 month long Nuffield study looking into ways we could stop the UK dairy industry from declining. It gave me the chance to have a break from my business and look at the dairy industry as a whole. Today I have the chance to share what I've learned from my travels. Here are the three key things I found:

Learn from the past - What past mistakes have affected where you are today?

Taking on the family business is a huge responsibility for anyone; since I was young I have never heard any of my family discuss how much they enjoy being a farmer. I have also never heard any of my family discuss how much money they have made from farming. As a child my image of farming was that you worked dawn till dusk, drove round in a beaten up truck and smelt of cows all day long (if you had a spot of cow muck in your ear then that was even better). How do you view yourself? Is your view of yourself built upon the foundations laid by the previous generation? It's important to ask yourself these questions, looking back is a great way of not repeating mistakes from the past. In the UK we have experienced the pressure that supermarkets can put on the farm gate milk price. We have also had many farmer owned Co-ops go bust and left farmers out of pocket or in some cases not received payments for milk supplied.

When we joined Arla Foods, now the largest milk processor in Europe, I simply looked at how it was structured to make sure I didn't end up losing money at some point. In 2007 a deal was struck with Tesco (our largest supermarket) to form a dedicated supply pool of milk. They did it on a geographical basis, contacting farmers on certain milk routes to join. The "carrot" was simple; they paid 21ppl instead of the 18ppl we were receiving from Arla at the time. They set some welfare and quality standards for us to follow in exchange for a better milk price. For me this was a given opportunity that needed to be jumped on. I hadn't experienced years of supermarket domination and it seemed the best way forward at that time. Older farmers were extremely sceptical about the whole deal especially when independent consultants were employed by Tesco to collect financial data from farms.

Tesco offered to pay an additional payment to any farmers who would submit their costings to produce a pooled average cost of production. Tesco would then use this COP to set the milk price, they also pay an extra amount for family labour, which on an average UK farm comes to £56,000 worth of income. Like it or not supermarket has the shopper exactly where they want them, in their shop! There has never been anything stopping farmers starting up their own supermarket chain using the same models that the like of Coles and Woolworths have used to become so powerful. It's good to remember this before you act the victim in the market.

Hard work doesn't guarantee success, but if you don't work hard you will never have a chance. Do you work hard or smart?

Today our business is going along well; we have made a consistent profit with a wildly varying milk price. Our dedicated supermarket contract has given us the confidence to invest in much needed infrastructure. My aim with this investment has always been to reduce overall costs to the business. In the UK we have a 50% domestic market so our exposure to the volatile world market is a lot lower than New Zealand. However we have always tried to reduce our cost of production. The Tesco milk pool has grown whilst the total UK production has declined. We are currently being paid the highest milk price our business has ever seen, but this has been driven mainly by rising input costs. The relationship between the farmers and the retailers has improved as more dedicated supply pools have been started by other retailers. Supply is tight and the shopper has become even less loyal making the retailers jumpy about their image on the high street. The UK has seen an influx of discount retailers who have started to take a chunk of the market share. I recently spoke to the key accounts manager at Arla who works with Asda. He told me that the shoppers are loyal for their big shop each week, but will stop anywhere to top up on whatever they need. Asda would be pleased to gain 5% of the retail market, last year the discounters gained over 20%. If the milk pool was dissolved for some reason we would simply go back to a standard contract with Arla. This would not destroy our business in anyway. I have read recently about how the Australian supermarkets are looking to set up similar contracts. My advice to you would be this, what do you have to lose by being a supplying farmer? I'm sure when man invented the wheel some said it wouldn't work. If it doesn't work out then go back to what you were doing before. This may sound reckless but I read a quote once that said this 'In order to succeed, your desire for success should be greater than your fear of failure'

Lack of direction, not lack of time is the problem. Where are you going?

I might be a third generation dairy farmer but I'm a first generation businessman. When I was travelling I asked myself and the farmers I met a few simple questions. The one that everyone struggled with the most was 'Where are you going?' I'm hoping that you understand that once you have found the answer to this question this will solve a lot of issues within your business. A ship without a rudder is going nowhere, in the building trade you simply build up a big business and invest cash into things that will generate income for you once you get too old to work. You may get lucky and be bought out by a bigger building company. I started to ask myself this question and thought for all the success we have been blessed with, I don't have a plan much past 50 years of age. So I looked at the past and present, addressed my attitude toward my business and came up with some goals. Here are my goals;

Joe and Becky Delves

Do what we choose to do at 60 with a 100k a year income. Be earning 40k a year at 40, 60k a year at 50. Adopt two boys before Becky is 35 and have an investment per child e.g. House/Flat, herd of cows, commercial units etc. Have a two week holiday abroad each year, which was a condition that Becky set when we moved into farming.

My business aims are simple, be in the top 10% of dairy businesses measured on profit. Have a good lifestyle and be able to help others achieve their dreams. I also have a policy of making a capital investment every year; this is so someone else doesn't buy a mess like I did.

Goal setting is not a common thing in agriculture but it helps the mind subconsciously make good decisions that will improve your situation within your business. These goals don't have to be business focused, they could simply be to have every weekend off or have a 2 week family holiday every year. These goals will drive progress in your business; they will make you question what you do and what you want to do. The biggest thing I noticed when travelling round was that farmers tended to focus on things they can't control such as the weather and global milk market. In New Zealand I meet a lot of drought affected farmers that were low on feed. Each farmer had a completely different attitude toward the situation they faced. Some positive, some negative. They sold their milk to the same milk buyer so each farm was facing the same income problems. You could argue that the different debt levels between the farms would have the greatest effect on their financial situation but to be honest the farmers with the more risky debt seemed more positive. This was a eureka moment for me when I realised the positive farmers were long term players and weren't focusing on the issue that was right in front of them. I was lucky enough to spend a day with Ian Handcock who runs an Ag coaching business in New Zealand called Target Focus. Ian confirmed what I was thinking, suggesting that farmers needed to be more professional in their approach to business.

CONCLUSIONS

'Myself, plus motivation, equals success!'

Where I was?

It's good to look back at your life and consider what led you to where you are. Think about any good or poor decisions you made that you wish you could undo. Sounds strange but it's good to look at what you've achieved so far and learn from any mistakes you've made along the way. Looking back shows you what you can accomplish as well.

Where I am?

Consider the tools you have in your hand. It might be money, or skills or just a desire to do better. Think about what you do day to day and consider which things you enjoy and which things you don't like. Where do you lack knowledge? Why does the business not make money? I made a big mistake when I bought into the farm, I never asked how much profit it had averaged over the past ten years and also didn't realise how big the under investment in infrastructure was. This put us under tremendous strain and almost cost me my marriage!

Where I want to be?

The BIG one, how do you want your future to turn out? Income is a big issue for us with young children. When they hit the 10 to 20 stage we will need to be running robust businesses that are shedding of enough cash each year for Ponies, school skiing trips and the endless burning of fuel as we taxi our kids around countryside. The best approach to this issue is to simply pitch your mind to your retirement. How old will you be? How much money will you need per year to live? Do you want to help your kids out with money? Then think back to now. How much income will you need when your 40? 50? 60? Do you want to private school your children? Do you want a holiday abroad every year? Does your wife want to have a separate career? These all sound like stupid questions to ask but they will help you to focus on the bigger things.

Finally write down three things you love about being a farmer, stick them on your fridge door and read them every morning before you leave the house. This will help you communicate better to everyone that farming is a fantastic career choice and should be open to anyone.

Thank you for reading this.

Joe Delves

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The use of partial mixed rations in pasture-based dairying in temperate dairying regions of southern Australia

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- When a PMR was offered at rates above 10 kg per day (7-8 kg concentrate) there were significant benefits in terms of milk solids production.
- Benefits observed in both early and late lactation from the use of PMR came from improved formulation of concentrate and forage when compared to feeding concentrate in the bail and conserved forage in the paddock;
- PMR based systems consistently arrested the milk fat depression that accompanied higher levels of supplementation in the bail;
- Despite the low levels of pasture offered, cows fed a carefully formulated PMR ate more pasture by grazing to lower residuals than would normally be expected;
- When canola meal replaced some of the wheat in PMR there were significant increases in milk solids production when higher amounts of supplement were offered.
- One experiment showed that offering a higher allowance of pasture increased intake from 3.6 to 4.5% of the cows liveweight; one of the first examples of intake greater than 4% in a grazing system. This represented an increase in dry matter intake for a 550 kg animal of about 5 kg per day with an associated milk production response.

INTRODUCTION

This paper focuses on the role of feeding systems that combine mixed rations and grazed pasture in the temperate dairying regions of Australia. These systems, in which a mixed ration is fed to cattle on a feed pad in between bouts of grazing, have been termed partial mixed ration (PMR) systems. New research findings on rumen fermentation, milk responses and feed conversion efficiency (FCE) within these systems are presented.

Feeding systems in Australia

The drivers for much of the new research on PMR feeding systems were below average rainfall, reduced availability of irrigation water and reduced pasture DM production during the particularly dry period between 1997/98 and 2007/08 in south east Australia. This led to an increased reliance on purchased forage and concentrates to meet the nutritional requirements of the milking herd. In addition, a wider range of supplements are now used, including an array of by-products, which has created further challenges in providing a balanced diet. Prior to this period of low rainfall, the primary feed for dairy cows in temperate Australia was grazed and conserved perennial ryegrass pasture, supported by rainfall or irrigation, and supplemented with cereal grain and purchased conserved forages. These pasture-based systems are inherently low cost and amongst the most efficient in the world.

To monitor changes in prevailing systems for feeding dairy cattle on Australian farms, Dairy Australia undertakes an annual dairy farm survey and categorises farms into five feeding systems according to characteristics of key feed inputs used (Dairy Australia 2012*b*). These are defined below.

System 1. Grazed pasture + other forages + up to 1.0 t/cow of grain and/or concentrates fed in the dairy during milking (low bail)

System 2. Grazed pasture + other forages + more than 1 t/cow grain and/or concentrates fed in the dairy during milking (moderate to high bail)

System 3. Pasture grazed for most or all of the year + partial mixed ration on feed pad ± grain and/or concentrates fed in the dairy (partial mixed ration)

System 4. Pasture grazed for less than 9 months per year + partial mixed ration on feed pad ± grain and/or concentrates fed in the dairy (hybrid)

System 5. Zero grazing. Cows housed and fed a total mixed ration (total mixed ration)

Results from a survey conducted in 2010/11 (Dairy Australia 2012*b*) showed that farms which grazed pasture and supplements offered on a feed pad (Systems 3 and 4), comprised 15% of dairy farms. Less than 3% of farmers in any region used System 5. However, farmers using Systems 3, 4 or 5 produced 26% of the total annual milk across Australia because they tended to have larger herds.

Farmers have also shifted to Systems 3, 4 or 5 (Dairy Australia 2012*b*) because of the potential to increase DM intake (DMI) and milk production per cow, to capture opportunities to use cost effective by-products and reduce wastage of supplements, to ameliorate heat stress and to minimise damage to pastures during wet weather.

Research into PMR feeding systems

Feeding supplements to grazing dairy cows as a PMR (System 3) has the potential to take advantage of the benefits of formulated mixed rations while maintaining a relatively low-cost feeding system based on grazed pasture. A well-formulated mixed ration that is consumed over a longer period of time during the day than when grain is fed in the bail could lead to a more stable rumen fermentation with less variation and lower declines in ruminal fluid pH. For this reason, Garcia and Fulkerson (2005) suggested that providing supplements to grazing cows as a PMR may lead to improved milk production responses compared with feeding concentrates in the bail. However, results from an annual dairy farm survey (Dairy Australia 2012*a*) showed that the average annual milk production from cows consuming PMR (System 3) was only slightly higher than for cows consuming moderate to high amounts of grain in the bail (System 2; 6483 versus 6310 L/cow per year, respectively). This indicates that farmers currently using PMR are not taking full advantage of the potential benefits of such feeding systems.

A series of seven short term experiments over four years have been conducted. The collective aim of these experiments was to determine the impact of form, type and amount of supplementation in conjunction with limited amounts of pasture in cows at different stages of lactation on milk production responses and FCE. Auldist *et al.* (2013a) conducted an experiment to measure milk production responses to feeding supplements in different ways. Cows in late lactation were offered either 6, 8, 10, or 12 kg DM of total supplement as either a maize-based PMR or as an iso-energetic ration of barley grain fed in the dairy and forage fed in the paddock (Control). These supplements were fed in addition to an allowance of 14 kg DM/cow.day (measured to ground level) of a perennial ryegrass based pasture. Results showed that when >9 kg DM total supplement was offered, marginal ECM production responses were greater for cows consuming PMR than the Control diet. Also, the supplement intake at which marginal ECM production response became negative (i.e. maximum milk production) was 1.5 kg of DM higher for PMR cows than Control cows. This was largely related to a marked decline in milk fat concentration as supplement intake increased in the Control cows, which was not present in PMR cows. In PMR cows, milk fat concentration remained constant at all supplement intakes.

The increased milk production response reported by Auldist *et al.* (2013*a*) was due in part to higher intakes of both supplement (less refusals) and pasture (PMR cows grazed harder into the sward despite very low residual pasture masses and an equal opportunity to graze). It was speculated that the maize portion of the PMR had digested more slowly than the predominantly barley grain-based diet of the Control cows, and that led to higher and more stable ruminal fluid pH, with associated increased intake. An experiment conducted by Greenwood *et al.* (2013) using cows consuming similar diets to Auldist *et al.* (2013a) in a metabolism facility showed this difference in ruminal pH very clearly. This difference in ruminal pH was also presumably related to the difference in milk fat concentrations, since low ruminal pH has previously been linked to increased production of specific biohydrogenation intermediaries with anti-lipogenic effects. However, Greenwood *et al.* (2013) found no difference between the Control and PMR diets in whole tract digestibility of DM, N, starch or NDF, despite the differences in ruminal pH.

Further experiments confirmed that, providing the PMR contained the same density of ME and CP, the milk production benefits of feeding high amounts of supplements as a PMR compared to feeding grain in the dairy were also apparent in early lactation when cows were mobilising body tissue (Auldist *et al.* 2013*b;* M.J. Auldist unpublished data, Table 1).

These experiments also showed that it is critical to consider the composition of the PMR and in particular the CP concentration. Reduced CP concentration in the PMR was shown to limit any benefit of the PMR over the Control diet in terms of milk production response.

Table 1: Mean daily dry matter intakes (DMI), live weights (LW), energy corrected milk (ECM) yields and feed conversion efficiencies (FCE) for cows offered varying amounts of supplements in different ways in three different experiments.

Treatment (kg DM supp/cow.day)	DMI (kg/cow.day)	LWT (kg)	DMI/LW (%)	ECM (kg/cow.day)	FCE (ECM/DMI)
			Auldist *et al.* 2013a		
Control (6)	15.4	581	2.7	16.7	1.08
PMR 1 (6)	14.9	595	2.5	15.1	1.01
PMR 2 (6)	15.8	598	2.6	16.4	1.04
Control (8)	17.2	600	2.9	19.5	1.13
PMR 1 (8)	16.7	596	2.8	18.3	1.10
PMR 2 (8)	17.6	598	2.9	19.6	1.11
Control (10)	18.4	571	3.2	21.4	1.16
PMR 1 (10)	18.4	618	3.0	20.3	1.10
PMR 2 (10)	19.2	605	3.2	21.7	1.13
Control (12)	19.9	592	3.4	20.2	1.02
PMR 1 (12)	19.1	602	3.2	20.0	1.05
PMR 2 (12)	21.6	616	3.5	22.1	1.02
			Auldist *et al.* 2013b		
Control (8)	17.7	542	3.3	26.0	1.47
PMR (8)	17.4	534	3.3	25.4	1.46
Control (10)	18.4	561	3.3	27.1	1.47
PMR (10)	19.5	538	3.6	27.4	1.41
Control (12)	19.7	548	3.6	28.3	1.44
PMR (12)	20.4	562	3.6	28.6	1.40
PMR+Canola (12)	20.9	546	3.8	31.7	1.52
Control (14)	20.8	561	3.7	29.3	1.41
PMR (14)	21.0	534	3.9	28.9	1.38
PMR+Canola (14)	23.5	563	4.2	30.5	1.30
			Auldist *et al.* unpublished [1]		
Control[2] (12)	20.2	584	3.5	34.0	1.68
Grain Mix[3] (12)	22.0	560	3.9	34.4	1.57
PMR lo[4] (12)	20.8	585	3.6	36.0	1.73
PMR hi[5] (12)	25.8	575	4.5	37.6	1.46

[1] *Unpublished data has not been statistically analysed nor covariate adjusted.*

[2] *Control - Wheat grain fed in dairy and Lucerne hay fed in paddock, concentrate:forage was 0.73:0.27 on DM basis, and pasture offered at an allowance (to ground level) of 15kg DM/cow.day.*

[3] *Grain Mix – Grain mix containing wheat, maize and canola meal fed in dairy at milking time and Lucerne hay fed in paddock (concentrate:forage was 0.73:0.27 on DM basis), and pasture offered at an allowance (to ground level) of 15kg DM/cow.day.*

[4] *PMR lo – PMR consisting of the grain mix and Lucerne hay (concentrate:forage was 0.73:0.27 on DM basis), and pasture offered at an allowance (to ground level) of 15kg DM/cow.day.*

[5] *PMR hi - PMR consisting of the grain mix and Lucerne hay (concentrate:forage was 0.73:0.27 on DM basis), and pasture offered at an allowance (to ground level) of 30kg DM/cow.day.*

The fact the PMR used in all the above studies contained a more slowly digestible starch source (maize) than the Control ration (barley or wheat) is also likely to be a contributing factor to the observed milk production benefits. This raises the possibility that feeding the grain portion of the diet to cows using the existing grain feeding infrastructure in most modern dairies could capture some of the milk production benefit observed with PMR systems without the need for farmers to purchase a mixer wagon and build a feed pad. This was tested in a large experiment at DEPI Ellinbank, in which the milk production of cows grazing a restricted pasture allowance and fed a formulated grain mix containing maize grain, wheat grain and canola meal in the dairy at milking times (with lucerne hay fed in the paddock), was compared to that of cows fed a PMR containing all four components and fed on a feed pad after milking. Results showed about half of the advantage of the PMR over the Control ration was obtained in this way, indicating that the benefits of the PMR are partially but not entirely related to the composition of the ration. In the same experiment, one PMR treatment group was allowed access to perennial ryegrass pasture in addition to up to 16 kg DM of PMR/cow.day. These cows were seen to consume their entire ration and still ate more pasture than cows on the restricted pasture allowance and, thus, produced more milk. This confirms previous observations (Auldist *et al.* 2013a) that cows consuming a well-balanced PMR have an enhanced capacity for DMI even when consuming very high amounts of supplement.

The deliberate strategy to restrict pasture intake in the experiments reported by Auldist *et al.* (2013a,b) resulted in DMI ranging from 2.5 to 4.2% live weight with a concomitant increase in ECM and FCE ranging from 1.01 to 1.52 kg ECM/kg DMI (Table 1). The potential to improve DMI was further demonstrated when pasture allowance restrictions were removed for cows consuming 12 kg DM PMR, with changes in intake from 3.6 to 4.5 % live weight, (20 to 25 kg DM/day for a 550 kg cow; Table 3, Auldist *et al.* unpublished). This represents one of the highest intakes reported in the literature for grazing cows and shows the potential for increasing milk yield in grazing systems. Energy corrected milk increased; however there was a small decline in FCE, which decreased from 1.7 to 1.5 kg ECM/kg DMI.

Economic analysis of PMR systems

Ho *et al.* (2013) used a whole farm approach to examine the potential economic benefits of implementing a partial mixed ration feeding system on two case study farms and found that profitability increased when feeding a partial mixed ration. However, risk, measured as variability in profit, also increased compared to a feeding system based on grain in the dairy and conserved forage in the paddock. A limitation of this study was the reliance on a large number of assumptions as there was limited data on substitution, changes in milk composition, and marginal milk responses to increasing supplements in partial mixed ration systems. Auldist *et al.* (2013a) provides the first data on milk production responses to partial mixed ration feeding for Australian conditions, and is being used to examine the economics of tactical (monthly/ seasonal) and strategic (annual/longer term) supplementary feeding decisions.

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Monitoring grazing behaviour of dairy cows in pasture based systems

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- Pilot study exploring the use of automated data collation technology to capture grazing behaviours
- Observed grazing time declined with increased concentrate feeding and observed grazing behaviour varied between individual cows
- The technology continuously logs providing grazing behaviour data and this could potentially be used to quantify pasture intakes and substitution rates
- Developing automated data collation technology of grazing behaviours as a means for estimating pasture intake and substitution rates would significantly advance the industry's ability to assess the impact of individually feeding cows to economically optimise

ABSTRACT

Continued improvement in the production and utilisation of pastures is essential to maintain the economic competiveness of dairy production systems in Australia. There are varying levels of concentrate feeding for pasture based dairy systems in Australia, ranging from zero concentrate allocation to over 2 tonnes of concentrate per cow per lactation. The optimal amount of concentrates required to achieve the most profitable milk production response is a question commonly asked and the response will be dependent upon several factors. One of the most influencing factors is the rate of substitution. In pasture based systems, it is often difficult to quantify how much pasture a cow substitutes as a result of concentrate feeding. Approaches to quantifying, at an individual animal level, how the grazing behaviour and associated pasture intake of dairy cows changes in response to concentrate feeding should significantly enhance our ability to optimise performance and profitability. This study monitored the grazing behaviour of 24 multiparous cows, in mid lactation, over a 10 day period which were receiving either 6.0 or 0.0 kg DM concentrates per day.

Grazing behaviours were monitored visually for three 2-hour periods, per day, for each of the 10 days. There was a significant effect of concentrate feeding level and time of day on grazing behaviour. Cows that were on a diet of 6.0 kg of concentrate per day were observed to spend 41% of their time grazing (defined as "cows in the act of eating") which was significantly less time than cows on 0.0 kg concentrates, which were observed to spend 67% of their time grazing. Observed grazing time was significantly higher following morning and afternoon milking compared to the period prior to afternoon milking. The coefficient of variation for the percentage of time observed grazing for the cows being fed 6.0 kg of concentrates per day was 0.38 compared with 0.20 for the cows receiving 0.0 kg concentrate. This indicates that the influence of concentrate feeding on time spent grazing, can varying quite significantly between individual cows. Developing automated data collation technology of grazing behaviours as a means for estimating pasture intake and substitution rates would significantly advance the industry's ability to assess the impact of individually feeding cows to economically optimise performance in a predominately pasture based system.

INTRODUCTION

In Australia, dairy farms are categorised into five varying farming systems (Dairy Australia 2011) and according to national farm survey results, 50% of Australian dairy farms are classified as farming system 2 (grazed pasture and other forages with > 1.0 tonne grain/concentrates fed in bail). Developing management strategies that optimise profit from concentrate feeding is a key requirement for the Australian dairy industry and furthermore, understanding how dairy cows adjust their grazing behaviour and associated pasture intakes in response to concentrate feeding will be vital to developing such strategies (Sheahan *et al.* 2011). It is well established that plant (sward structure, species, nutritive value, seasonal conditions), management (herbage allocation, stocking rate, supplementary feeding) and animal (genotype and individual idiosyncrasies*)* factors are capable of modifying the grazing and rumination pattern of lactating dairy cows (Dillon 2006).

Influences of herbage allowance and concentrate feeding level on grazing behaviour and associated herbage intake have been widely researched with reductions in herbage intake as the level of concentrate feeding increases (Bargo *et al.* 2003) and higher pasture intake with greater pasture allowance is well defined (Dalley *et al.* 1999). Substitution rate and the marginal milk response (Stockdale 2000) for a given situation are defined at whole of herd level. With increasing rates of adoption of dairy parlour infrastructure allowing for individual bail feeding of dairy cows, development of technologies that allows the capture of individual cow grazing behaviour will assist in the development of individual cow bail feeding decision rules, potentially leading to enhanced profitability from concentrate feeding. The aim of this pilot study was to undertake detailed individual cow observations of grazing behaviours (e.g. the timing and length of grazing and rumination bouts) for cows offered different levels of concentrates during milking and to evaluate the use and efficacy of GPS collars and motion sensors to capture and record such grazing behaviour.

METHODS

This study was conducted on 24 Holstein-Friesian multiparous cows selected from the Tasmanian Institute of Agriculture Dairy Research Facility at Elliott, 41°5'S, 145°46'E. Two groups consisting of 12 cows were established and balanced for means and variances (± SD) of milk production (25.0 ± 3.9 litres per day), days in milk (71± 9 days), body weight (480 ± 34 kg), and age (4.6 ± 1.9 yr). Each group of cows was allocated to one of two concentrate feeding levels. Cows received 50% of their concentrate feed allocation of 6.0 or 0.0

kg DM/day of Coprice® Dairy Pellets (CP = 14% of DM; ME = 12 MJ ME/kg of DM) twice daily during milking via automatic feeders (ALPRO System, Alfa Laval Agri, Sweden). Cows were milked twice daily through a herringbone parlour at approximately 0630 and 1530 h. Milk yield for each cow at each milking was recorded using DeLaval's Alpro Herd management System (DeLaval International, Tumba, Sweden). Feeding treatments commenced on 25th of October 2012 and ceased on 31st December 2012. Pastures grazed were predominantly perennial ryegrass and cows were rotationally grazed as one herd, with daily forage allocation allowance of approximately 30kg DM/cow/day of feed on offer above ground. Between the dates of 28th November 2012 and 7th December 2012, cow grazing behaviour was intensively monitored. The proportion of time spent grazing (defined as "cows in the act of eating"); ruminating and resting (not grazing or ruminating) was determined by recording a cow's activity for a continued period of 30 minutes. Grazing behaviour data was recorded via the digital application What See (© Timothy Heuser, 2009). Grazing behaviour was monitored during the 2 hour period immediately following morning milking (M), between 12:00pm and 2.00pm (L) or during the 2 hour period immediately following afternoon milking (A). Each of the 24 cows was monitored at least once (mostly twice) during each of three observational periods and where multiple recording occurred the mean recording for the individual cow during that observational period was calculated. This resulted in 72 (24 cows by 3 time periods) data entries.

The proportion of time spent grazing and ruminating was calculated and transformed using the arcsine root transformation. Transformed data was analysed as a two-way factorial ANOVA (feeding treatment by observation period) with mean milk daily production in the preceding week used as a covariate. The proportion of time spent grazing for each cow was regressed against the mean daily milk production recorded over the observation period. In addition, each of the 24 cows was fitted with a collar which consisted of a Fleck^{TM} (Sikka *et al.*, 2004) with wireless networking. The collar had a number of sensors including GPS, 3-axis accelerometer, 3-axis magnetometer and data storage capacity. The collar number, time (seconds), latitude and longitude were collected and saved in the dataset. The dataset generated from the cow collars combined with observed behaviour will be used to establish algorithms that allow for the generation of a model that can capture the behaviour of the animal, at time intervals of a second, for continuous periods. At time of writing the data from cow collars was not available and is not presented.

RESULTS AND DISCUSSION

There was a significant ($P < 0.05$) effect of grain feeding on time observed grazing. For cow's receiving 0.0kg DM concentrates the proportion (mean ± s.e) of time observed grazing was 0.67 ± 0.05, compared to 0.41 ± 0.05 for those cows receiving 6.0kg DM of concentrates. Similarly, the time spent ruminating was also significantly ($P < 0.05$) affected by grain feeding. For cow's receiving 0.0kg DM of concentrates the proportion of time (mean ± s.e) observed ruminating was 0.11 ± 0.04, compared to 0.21 ± 0.04 for those cows receiving 6.0kg DM of concentrates. There was a significant ($P < 0.05$) effect of observation time on activity. The proportion (mean ± s.e) of time cows were observed grazing in the morning (M) and afternoon (A) period was 0.66 ± 0.07 and 0.59 ± 0.06, respectively, which was not significantly ($P > 0.05$) different. The proportion (mean ± s.e) of time cows were observed grazing during the lunch period (L) was 0.37 ± 0.06, which was significantly ($P < 0.05$) less than that observed in the M and A period.

Similarly, the proportion (mean ± s.e) of time cows were observed ruminating in the M and A period was 0.10 ± 0.02 and 0.05± 0.01, respectively, which was not significantly ($P > 0.05$) different. The proportion (mean ± s.e) of time cows were observed ruminating during the L period was 0.33 ± 0.07, which was significantly ($P < 0.05$) higher than that observed in the M and A period. There was no significant ($P > 0.05$) interaction between grain feeding level and observation period on observed time spent grazing or ruminating (Figure 1). The observation that cows spend less time grazing when offered concentrates compared to cows that receive no supplementation is consistent with other studies (e.g. Hernandez-Mendo and Leaver 2006; Rook *et al.* 1994), and that the bouts of grazing occur after the morning and afternoon milking is also consistent with other studies (e.g. Sheahan *et al.* 2011; Soriano *et al.* 2000).

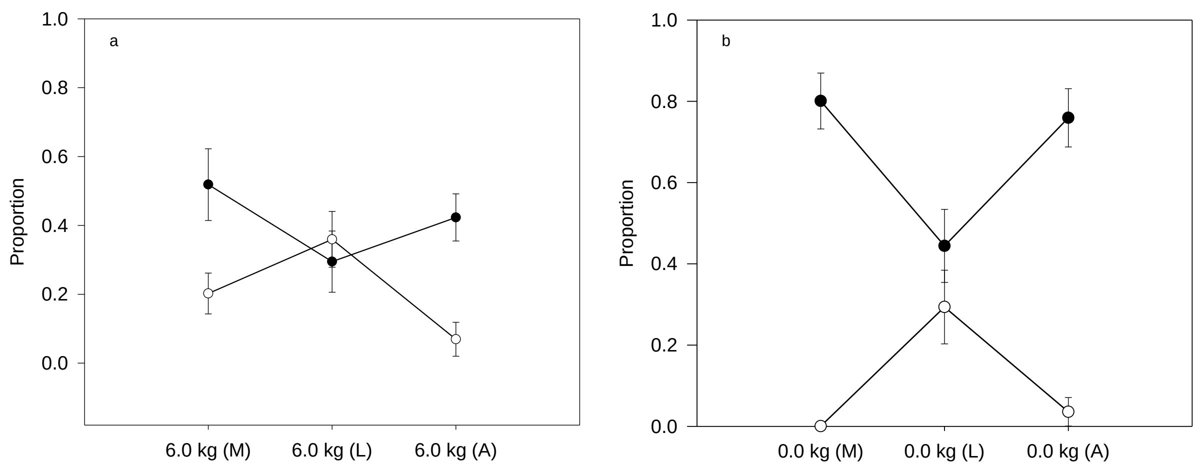

Figure 1: The mean proportion of time cows were observed grazing (closed circle) or ruminating (open circles) that were receiving either 6.0 kg (a) or 0.0 kg (b) concentrates per day, during the 2 hour period immediately following morning milking (M), between 12:00pm and 2.00pm (L) or during the 2 hour period immediately following afternoon milking (A). Error bars represent standard errors of the mean.

The daily milk production (mean ± s.e) of the twelve cows in the group receiving 0.0kg DM of concentrates was 16.5 ± 1.0 litres.day^{-1} compared to 22.4 ± 1.0 litres.day^{-1} for the cows receiving 6.0 kg DM of concentrates. Although the feeding treatments imposed were not principally established to determine the marginal response to concentrate feeding, the observed marginal milk response of approximately1.0 kg milk/kg concentrate DM is consistent with other studies (Sheahan *et al.* 2011) and that reported in Dillon (2006) when pasture substitution rate is 0.25 kg/kg. There was a 39% decline in time observed grazing for cows receiving 6.0 kg of concentrate compared to the non-supplemented cows and although the observational data does not capture actual intake, this result and the observed marginal milk response indicate that some level of substitution of pasture was occurring. Further analysis of the data captured from the cow collars deployed in this study will attempt to quantify the level of substitution of pasture that has occurred in this study.

A negative linear relationship between proportion of time observed grazing and mean daily milk production was found with nearly 40% of the variation in milk production explained by this relationship (Figure 2). This however was a result that the cows on the 6.0kg DM of concentrate were observed to be grazing only 0.41 of the time compared to 0.67 of the time for cows getting 0.0 kg DM of concentrates.

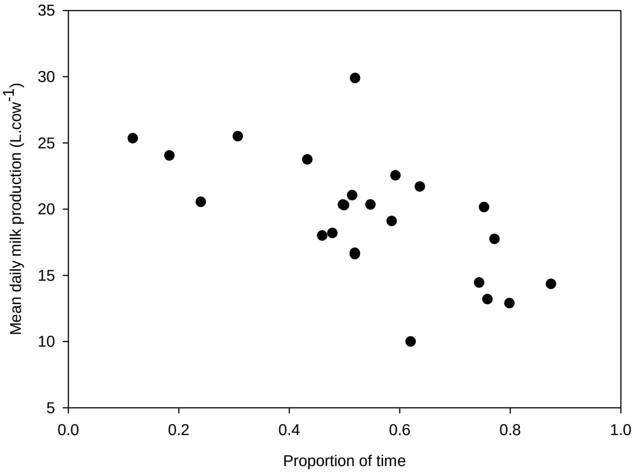

Figure 2: Linear regression analysis of the mean proportion of time cows were observed grazing and mean daily milk production over the experimental period.

Linear regression analysis of proportion of time observed grazing against mean daily milk production for each of the two feeding treatment groups found that < 15% of the variation in milk production could be explained by time observed grazing (Figure 3a). This was also true when compared for each time period (Figure 3b,c,d) and indicates that measurements of grazing time alone will not provide good estimation of milk production. According to Stobbs (1974), measurements of biting together with estimates of bite size provides a more accurate measure of feeding behaviours than grazing time. The use of the 3-axis accelerometer and 3-axis magnetometer sensors deployed on the cows in this pilot study and the data captured will be analysed and algorithms developed in attempt to provide such measures.

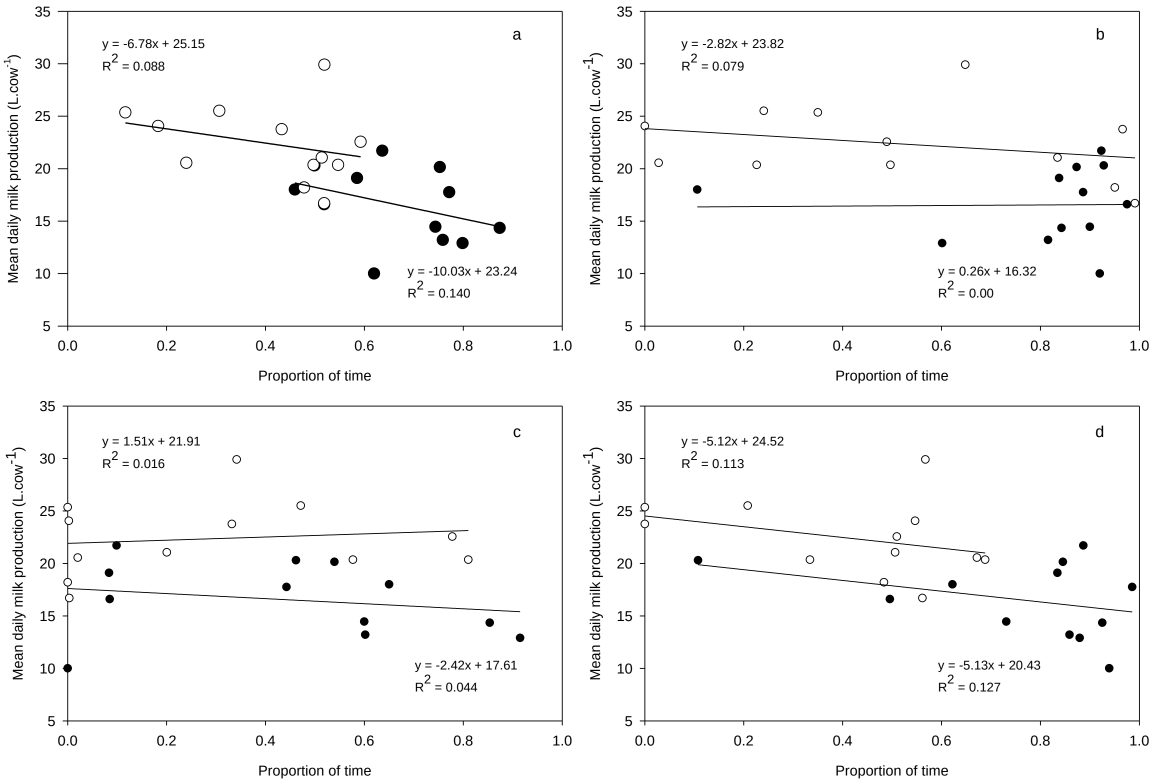

Figure 3: Linear regression analysis of the mean proportion of time cows were observed grazing averaged over each time period (a) or during the 2 hour period immediately following morning milking (b), between 12:00pm and 2.00pm (c) or during the 2 hour period immediately following afternoon milking (d) against mean daily milk production for cows being fed 6.0 kg DM of concentrates (open circles) or 0.0 kg DM of concentrates (closed circles).

The coefficient of variation (CV) for the proportion of time observed grazing for the cows being fed 6.0kg DM of concentrates was 0.38 compared with 0.20 for the cows receiving 0.0 kg DM of concentrate, indicating the influence of concentrate feeding on cow grazing behaviour, particularly time spent grazing, may varying quite significantly between individual cows, although the observational method adopted in this study may have contributed to the variation. The CV of proportion of time observed grazing during each observation period was always higher for the cows receiving 6.0 kg DM of concentrate compared to those receiving 0.0 kg DM of concentrate. The CV of proportion of time observed grazing for cows receiving 0.0 kg DM of concentrate was 0.30, 0.70 and 0.33 during the M, L, and A observational periods, respectively and 0.70, 1.04 and 0.56, respectively, for the cows receiving 6.0 kg DM of concentrates. This also indicates that greatest variation in time spent grazing occurs during the L period than the periods immediately following milking. By examining individual cows behavioural data captured by the cow collar sensors, at short (second) time intervals, will provide a means for confirming the individual behavioural variations. Such data may provide a method of quantifying individual cow intakes and individual cow substitution rates when offered varying levels of concentrates.

CONCLUSION

Technology, such as the cow collar sensors deployed in this pilot study, in combination with individual bail feeding technologies could potentially result in the development of new feeding approaches to economically optimise cow performance in predominately pasture based systems. This study has confirmed that time spent grazing declines as concentrate feeding level is increased and significant between cow variations in observed grazing behaviours (bout of grazing and rumination) may exist. The observed marginal milk response of 1.0 kg milk/kg concentrate DM was consistent with previous studies and suggests that some substitution may have occurred, although further analysis of the individual cow behaviour captured from the cow collar sensors is required to confirm this and to explore the individual cow variation in pasture substitution rates. Such data and technologies will be required to develop and research new approaches to optimise individual bail feeding of dairy cows in pasture based systems.

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TMR in Queensland: 'Total Mixed Ration, or 'Total "Missing" Ration'?

D. Barber

DAFF, Queensland

- Purchased feed and forage supply is critical in TMR feeding systems
- Balancing diets based on tropical forages is challenging
- TMR feeding systems are profitable but are dependent on production per cow and management skills.

INTRODUCTION

The use of conserved forages and intensive dairy feeding systems has increased dramatically on northern dairy farms over the last 10 years due to a number of factors, including drought, variable milk price and the processors requirement for a flat milk supply. With these external factors, dairy farms have looked at intensification and mixed ration feeding systems as a way of increasing stocking rate, production per cow, total farm production and profitability.

In a subtropical environment there are a number of key factors that influence the productivity and profitability of dairy farms, including climate, subtropical forages, forage quality and heat stress. These factors can have positive and negative effects and add another degree of management skill required to optimize profit. With these challenges, approximately 30 to 40% of subtropical dairy businesses have adopted partial and total mixed ration systems, with 10% of those farms using total mixed ration (TMR) feeding systems all year round (Chataway *et al,* 2010).

THE FACTS ABOUT TMR FARMS IN QUEENSLAND

TMR feeding systems based on tropical forages in Queensland are typically located in drier regions on the northern Darling Downs and southern Burnett regions with larger land areas compared to coastal farms. In the 2012 Queensland Dairy Accounting Scheme (QDAS) dataset, Darling Downs TMR farms had an average effective dairy area of 486 hectares, which was 326 ha greater than pasture-based farms in the southeast coastal regions of Queensland (Murphy *et al.*, 2012). Production per cow in 2012 for TMR farms was 7,132 litres/cow on average compared to 5,617 and 5,604 L/cow for southeast coastal PMR and pasture-based farms respectively (Murphy *et al.*, 2012), however the range in TMR farms is between 5,500 to 10,000 L/cow. Stocking rate was approximately 1.2 cows/ha and average number of cows was 249 (milkers + dry cows). Cow numbers have been steadily increasing over the last 4-5 years. There has been considerable investment into commodity sheds and feed storage in the past 10 years, with covered feedpads and freestall barns starting to be built in the last 2 years. The average investment per cow is approximately $14,000 with the majority of that investment tied up in land (Murphy *et al.*, 2012).

Forage base - Crops instead of pastures

Dairy farming in a subtropical region has its advantages and disadvantages with forage production. The warmer climate and accessibility to tropical forages means that growing large amounts of forage is relatively easy to achieve if access to water and land is available. The typical forages being used as the forage base in TMR diets are maize, barley, oats, soybean, forage sorghum and grain sorghum varieties grown as single, double and triple crops for silage depending on location, water and land availability.

A recent study in southeast Queensland achieved up to 42 tonne of dry matter (DM) per hectare with a triple cropping system of 2 crops of corn and one crop of barley harvested as silage within a twelve month period (Callow *et al.* 2009). Individual crops of corn, sorghum and barley have yielded in excess of 20, 12 and 10 tonne DM/ha on- farm. Moving towards conserved forages such as silage and hay and away from pastures has allowed farms to manage their feedbase more strategically to reduce some of the risk around feed supply. The use of cereal based silages as the primary forage source in TMR feeding systems has also increased the starch and metabolisable energy intake, resulting in higher milk yields, increased milk protein concentrations and improved body condition scores (Barber, 2008).

The downside to increased forage yields is often a reduction in forage quality, particularly seen as an increase in neutral detergent fibre (NDF) and a reduction in crude protein content and digestibility, however this is often offset by the increased starch and ME of cereal based silages (Table 1). This has resulted in a higher reliance on purchased feed commodities such as protein meals and byproducts to balance diets for optimum intake and milk yield in TMR systems. Another disadvantage associated with cropping versus pastures is the increased risk around losing crops due to climate variability, particularly in summer due to drought or high rainfall at harvesting.

Table 1: Range in dry matter yield and crude protein (CP), metabolisable energy (ME), neutral detergent fibre (NDF), starch and sugar concentration of forages grown as silage in a subtropical environment (Barber *et al.*, 2008).

Forage	Expected Yield (t DM/ha)	Crude Protein (% of DM)	ME (MJ ME/kg DM)	NDF (% of DM)	Starch (% of DM)	Sugar (% of DM)
Corn	15 - 25	6.6 - 11.0	9.2 – 11.2	37.2 – 58.3	2.4 – 39.9	1.2 – 9.6
Forage sorghum	8 - 15	6.9 – 11.9	7.3 – 11.2	38.9 – 68.2	0.9 – 32.3	0.3 – 12.9
Barley	8 - 12	6.5 – 16.3	8.4 – 13.3	41.4 – 63.2	1.9 – 30.6	2.7 – 22.8
Oats	5 - 8	8.0 – 23.9	8.9 – 11.1	45.1 – 61.8	0.1 – 13.9	4.0 – 23.3

Consistent feed supply

The supply of high quality feeds is critical in all dairy feeding systems, particularly the availability of high quality home-grown forages. The amount of forage grown is often not the main issue for TMR systems, as tropical forages such as forage sorghum have relatively high yields of dry matter per hectare. Higher DM yields in conjunction with larger land areas means that larger amounts of forage can be grown and stored to achieve a consistent forage supply for up to 2 years.

A consistent forage supply results in a flatter milk supply across the year and allows farms to maintain their feed costs at a relatively stable level depending on the amount of purchased feeds being used. Whilst tropical forages tend to have higher yields, they tend to have lower concentrations of crude protein and higher fibre levels. Increased fibre in the diet has a two-fold effect, it lowers dry matter digestibility and decreases potential intake (Mertens, 1994), which is an important driver of higher production per cow in TMR systems.

TMR farms in subtropical regions do have a higher reliance on purchased feed commodities to allow them to increase the quality of the diet to drive milk production. Increasing crude protein of the diet has been achieved through the use of protein meals and byproducts such as soybean meal, canola meals, whole cottonseed, millrun, brewers grain and distillers grain, which in turn also reduces the fibre levels in the total diet. Purchased commodities including grain and protein meals make up 50 to 60% of the diet on TMR farms, and therefore has placed a higher importance on the price and availability of commodities within the region. Most of the profitable TMR farms in Queensland forward purchase commodities with the aim of reducing total feed costs, reducing the variability in feed costs and to ensure a consistent supply of feed commodities across the year to support higher production per cow.

Nutritional and feed conversion efficiency targets

Nutritional targets for dairy cows in Australia have typically been based on metabolisable energy (ME) and crude protein (CP). This system works well in pasture based feeding systems, but has limitations in tropical forage based TMR systems and when there are more than 2 to 3 feeds in the diet. Nutrition-based models developed for balancing diets in North America have been useful in Queensland; however they require the analysis of individual nutrients in feeds to make them work effectively. Analysing feeds for starch, sugar, neutral detergent fibre (NDF), fat and mineral concentration has become an integral part of managing TMR systems and in developing a database of tropical forage quality (Barber *et al.*, 2008). The main challenge when balancing TMR rations based on tropical forages is achieving high levels of DM intake when NDF levels are high in the total diet.

Target DM intakes in TMR systems are typically between 23 and 26 kg/cow.day^{-1} on average, with a target of 28 to 32% NDF in the total diet. A feed residual of 2 to 5% is targeted to ensure all animals have access to feed over a 24 hour period. Achieving sufficient fermentable carbohydrate levels in the rumen is also a challenge when feeding tropical forages as it is an important requirement in the rumen. Tropical forages with higher fibre levels have a lower amount of fermentable carbohydrates when compared to temperate forages such as ryegrass. Hence, higher levels of starch and sugars need to be added to the diet from other sources to increase the amount of fermentable carbohydrate available to the rumen microorganisms, and to achieve higher ME intakes and milk production responses. The target concentrations of the main nutrients required in TMR systems is listed in table 2.

Table 2: Nutritional targets for total mixed ration feeding systems (Chopping *et al*, 2006).

Nutrient	Target in total diet (% of DM)
Crude protein (CP)	16 – 18
Neutral detergent fibre (NDF)	28 – 32
Acid detergent fibre (ADF)	18 – 19
Starch	22 - 25
Sugar	6 - 7
Fat	max 5 – 6 (3.5% ideal)

Feed conversion efficiency (FCE) is a measure of efficiency at which feed is converted into milk and is calculated as the amount of energy corrected milk (corrected for fat and protein concentration) produced per kg of DM eaten. The target for TMR systems in Australia is 1.6 L/kg DM or 120 grams of milk solids/kg DM (Dairy Australia, 2010).

A recent study that surveyed 70 farms across Queensland in summer and winter and collected over 800 feed samples from these farms, found a large range in FCE across all types of feeding systems (Callow *et al.*, unpublished data).

However, TMR systems tended to have a higher FCE compared to pasture and PMR based systems and there was slightly less variation seen across TMR farms compared to other feeding systems (Figure 1). The average FCE for TMR farms in summer and winter was 1.15 and 1.23 respectively, which suggests that heat stress management is important in these systems and that forage quality is playing a big role in the efficiency of feed conversion as the range in FCE across these farms was large (0.9 to 1.65; Figure 1).

Increasing FCE will reduce feed related costs and have a positive impact on profitability in TMR systems where feed costs tend to be higher. However achieving higher levels of FCE in TMR systems is also highly dependent on management and infrastructure available on farm. A specific set of management skills with a nutritional focus is required by both the farm manager and the person mixing the feed within TMR systems to ensure a consistent supply of feed is delivered on a daily basis.

Minimizing heat stress in a sub-tropical environment will also improve FCE, which was seen when comparing the average FCE for summer and winter in Queensland FCE survey. Hence, achieving FCE targets in TMR systems will be dependent on balancing the diet, consistency in feed supply, management skills and the provision of shade to mitigate heat stress.

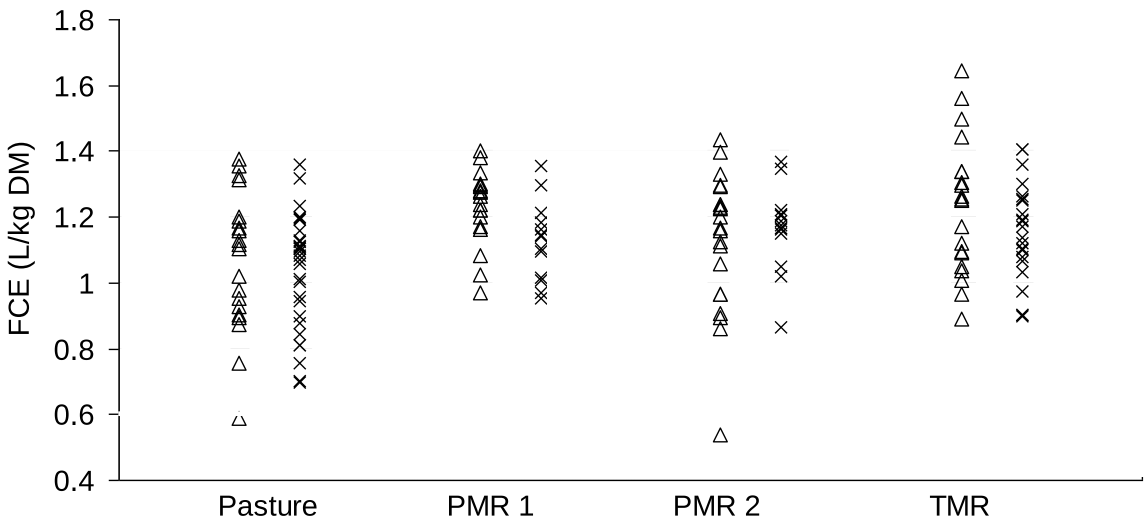

Figure 1: Feed conversion efficiency (L energy corrected milk/ kg DM intake) of 70 farms across Queensland surveyed in summer and winter (Callow *et al.* unpublished data).

Cost of production and profitability

The average price for milk has increased by approximately 21 c/L on farms within the Queensland Dairy Accounting Scheme over the past 10 years (Busby *et al*, 2002; Murphy *et al*, 2012). Milk supply has also increased in autumn due to a shift from Spring whilst total milk produced in Queensland has declined by 35% from 744 M litres in 2002 to 485 M litres in 2012. The shift to producing milk in autumn has increased the number of PMR and TMR systems due to their ability to flatten the feed supply and milk supply across the year; however it has also resulted in higher production costs.

Total operating costs has increased by 23.6 c/L over the past 10 years (26.4 to 50.0 c/L from 2002 to 2012) on farms within QDAS, with TMR farms operating costs at 52.5 c/L in 2012 (Busby *et al*, 2002; Murphy *et al*, 2012). Total variable costs and feed related costs on TMR farms was 33.2 and 30.1 c/L in 2012, which has decreased by 3.2 and 3.8 c/l respectively since 2009 (Busby *et al.*, 2009). Southeast coastal PMR and pasture based farms had total variable costs that were 5 c/L lower than TMR systems, with feed related costs also lower by 5.3 to 6.3 c/L respectively (Murphy *et al*, 2012). The lower feed related costs were primarily due to lower purchased feed costs within PMR and pasture base systems.

The production costs of TMR feeding systems are inherently higher when compared to pasture or PMR based systems, primarily due to higher feed related and purchased feed costs. However, profitability is higher on TMR systems compared to southeast coastal pasture and PMR based feeding systems. The average dairy operating profit per cow on the QDAS TMR farms in 2012 was $648/cow with a return on assets of 4.2% (Murphy *et al*, 2012). The dairy operating profit of PMR and pasture based farms was $448 and $550/cow in 2012 and return on asset was 2.2 and 3.0 respectively.

Over the past 5 years, dairy operating profit has declined across all feeding systems, however TMR feeding systems have had higher profit margins compared to PMR and pasture based systems. There is a lot of variation between farms and across feeding systems, with the main driver likely to be production per cow (Figure 2). The other benefit seen on TMR farms is that the risk around feed supply is less than seen in pasture based systems, therefore feed related costs can be maintained at a relatively constant level across the year and between years, often resulting in higher operating profit margins.

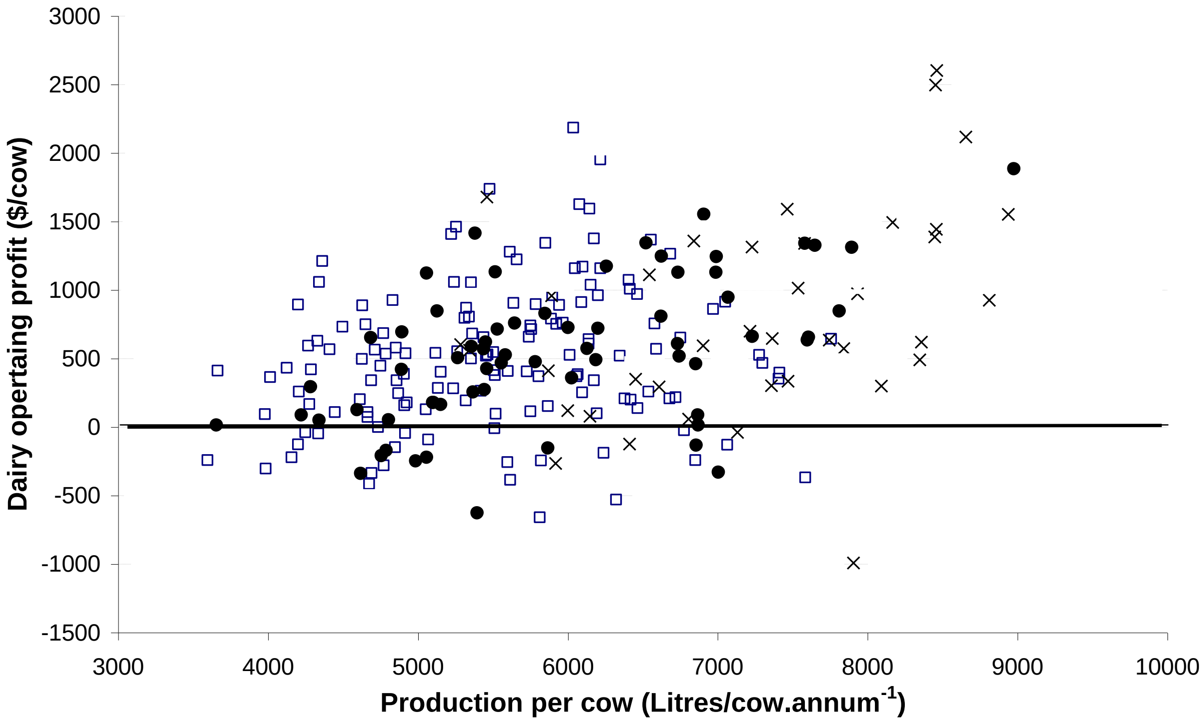

Figure 2: Distribution of production per cow (L/cow.annum^{-1}) with dairy operating profit ($/cow) for pasture (□), partial mixed ration (●) and total mixed ration (x) feeding systems within Queensland from 2007/08 to 2011/12 (R. Murphy, pers. comm. 2013)

CONCLUSION

Market and climate driven changes in northern Australia have forced dairy farms to modify their feeding systems to improve profitability, reduce risk and increase resilience. TMR feeding systems have increased in number over the past 10 years with many of them being based in drier regions where dryland pasture production was limiting production gains. Advantages have been gained through tropical forage crops, but they have also provided nutritional challenges around balancing the diet and driving production per cow. Profitability tends to be higher on TMR farms, however production per cow and management skills are key driver of profit in these systems. Total mixed rations have improved the productivity and profitability of some farms in northern Australia and the only thing 'missing', are long term market signals from processors to ensure these systems are profitable and sustainable into the future.

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Achieving more with your feeding system through genetics: Key findings from ADHIS's *Feeding the Genes* research project

S. Little

C and S Little Animal Production

Consulting for ADHIS and Dairy Australia

- Genetics do matter in all five main feeding systems, from Low Bail through to TMR.
- In all five main feeding systems, daughters of high APR bulls produce more milk, and are no less likely to last in the herd than daughters of lower APR bulls.
- Feeding high rates of supplements or mixed rations are not essential to benefit from selecting high APR sires.
- Dairy farmers using a high input feeding system receive the greatest benefit from selecting high APR bulls.
- Selecting high APR bulls isn't difficult. Simply stick with bulls on the Profit list in the ADHIS Good Bulls Guide.
- The semen of the top 50 bulls listed in the Good Bulls Guide does not necessarily cost more than that of other bulls.
- Dairy herd nutrition advisers can be confident in promoting the use of high APR bulls to their clients regardless of the feeding system being used.

"Do genetics really matter in all feeding systems?"

"Do farmers using different feeding systems have more or less to gain from choosing semen from high genetic merit bulls?"

"Is choosing semen from high genetic merit bulls really worthwhile if you are using a high input feeding system?"

“Are Holstein-Friesian cows with high genetic merit sires more likely to crash and burn than other cows in a low input pasture-based feeding system?”

“Should dairy nutrition advisers promote the use of high genetic merit bulls? If so, how difficult is it to provide useful advice?”

These are great questions that dairy farmers and nutrition advisers have been asking since the diverse range of feeding systems used on Australian dairy farms was categorised into five main types several years ago based on the extent of pasture grazing during the year, grain / concentrate feeding rates per cow per year, and feeding infrastructure and equipment used.

THE FIVE MAIN FEEDING SYSTEMS

1. Low Bail system

(Grazed pasture + other forages + up to 1.0 tonne grain/concs/cow/year fed in bail).

2. Moderate-high Bail system

(Grazed pasture + other forages + more than 1.0 tonne grain/concs/cow/year fed in bail).

3. PMR system

(Pasture grazed for most or all of year + partial mixed ration on feed pad ± grain/concs fed in bail).

4. Hybrid system

(Pasture grazed for less than nine months per year + partial mixed ration on feed pad ± grain/concs fed in bail).

5. TMR system

(Zero grazing. Cows housed and fed total mixed ration)

Unfortunately however, without any solid evidence available, definitive answers to these questions have not been available. That is, until now.

Dairy farmers and nutrition advisers can now be very confident they can achieve more with any feeding system by using better bred (high APR) bulls, following completion of the ADHIS ***Feeding the Genes*** study under the guidance of a project reference group.

This study has generated a comprehensive, new evidence base spanning the past five years, from over 500 Australian dairy herds. Using this data the effects of the Australian Profit Ranking (APR) and Australian

Breeding Value (ABV) on milk production of dairy cows, and the ability of cows to last in the herd have been investigated specifically for the five main feeding systems.

WHAT IS THE AUSTRALIAN PROFIT RANKING (APR)?

The Australian Profit Ranking (APR) is the main breeding index available for Australian dairy sires. It reflects nine traits that influence net farm profitability in Australia, including production (milk, fat and protein yields) and non-production traits. Non-production traits include survival (longevity), fertility, mastitis resistance, liveweight, temperament and milking speed. By using the APR, Australian farmers can expect to breed more profitable cows under Australian conditions. The higher the APR, the more profitable the bull.

WHAT ARE AUSTRALIAN BREEDING VALUES (ABVS)?

ABVs are the best estimate of the genetic merit of animals in the Australian environment. ABVs are not an absolute measure of how much an animal will produce. Rather, ABVs are expressed relative to each other using a base point (average). Farmers can compare individual animals against the average or compare animals against each other to determine the superior animal for a particular trait. The average is set at 0 for production traits and 100 for nonproduction traits and is updated annually.

HOW THE '*FEEDING THE GENES*' STUDY WAS CARRIED OUT

Study herds

Feeding the Genes was a retrospective study. Managers of 2,016 herds in the ADHIS database were invited to complete a questionnaire to categorise their feeding system. Responses were received for 513 herds and 505 of these herds were then enrolled in the study.

- The 505 enrolled herds were from all Australian states, with the distribution of herds by state similar to that for all Australian herds
- The majority of study herds were seasonal or split calving
- The Moderate-high Bail feeding system (system 2) was used by about two-thirds of the study herds
- Within herds, feeding system was quite consistent across the 5 years of the study
- 250,857 lactations were analysed for milk yield from Holstein-Friesian cows
- 43,941 lactations were analysed for milk yield from Jersey cows
- 11,000 lactations were enrolled in each of the five feeding systems from Holstein-Friesian cows. However, lactations with the Hybrid and TMR feeding systems (systems 4 and 5) were from relatively few herds

- There were far fewer lactations in all feeding systems from Jersey cows, with few in system 4 and none in system 5

Data collection and analysis

Cow, lactation and sire data for the 505 study herds were collected from ADHIS. APRs and ABVs were calculated on 20th August, 2012 using standard 305 or 300 day lactation yields.

Average milk yield for lactations analysed from Holstein-Friesian cows were 7,389 litres for all study herds, ranging from 6,121 litres for those using a Low Bail feeding system (system 1) to 9,471 litres for those using a TMR feeding system (system 5).

The change in milk volume, fat and protein yields were estimated for each 50 unit increase in the cow's sire's APR. (To put this in perspective, disregarding the top sire, 50 units was the difference in APR between the second to seventeenth Holstein-Friesian listed sires and the second to twelfth Jersey listed sires in August 2012).

The effect of APR (and ABVs) on the ability of cows to last in the herd were also assessed using two indicators:

- The odds of re-calving by 20 months, using all eligible lactations for each cow (Cows that have not re-calved by 20 months are at much greater risk of being culled. This is therefore a measure of survival in the herd)

- The odds of short lactations (less than 120 days). (A large proportion of cows with short lactations are likely to have had health problems around calving that seriously affected their milk production)

(Note – While the InCalf fertility data study concluded that daughters of higher fertility ABV sires are more fertile than daughters of lower fertility ABV sires, this study did not have sufficient lactations to precisely assess the interactions between APR (and ABV) and feeding system on reproductive performance).

Key study findings

The *Feeding the Genes* study has confirmed:

- Genetics do matter in all five main feeding systems.

- In all five main feeding systems, daughters of high APR bulls produce more milk, and are no less likely to last in the herd than daughters of lower APR bulls.

- Dairy farmers using a high input feeding system receive the greatest benefit from selecting high APR bulls. However, you do not need to feed high rates of supplements or use mixed rations to benefit from selecting high APR sires.

A. Australian Profit Ranking (APR)

Cow's sire's APRs for Holstein-Friesian cows whose lactations were analysed ranged from minus 250 to plus 300. The distribution of cow's sire's APRs for Jersey cows studied was slightly wider, from – minus 450 to plus 300. The highest sire APRs for study cows were similar to those for current highest-ranked sires in ADHIS's Good Bulls Guide (August 2012 edition).

For Holstein-Friesian cows, average sire APRs were lower in the PMR, Hybrid and TMR feeding systems (systems 3, 4 and 5) with similar variability across feeding systems. Means of sire APRs were markedly lower for Jersey cows. For both breeds, there was greater variability in APR within herds than between herds.

B. Effect of APR (and ABVs) on milk production between feeding systems

For Holstein-Friesians, as shown in Table 1, for each 50 unit increase in the cow's sire's APR, milk volume for the standard lactation was estimated to increase by 54 to 110 litres across the five feeding systems, fat yield by 1.5 to 5.7 kg and protein yield by 2.6 to 5.1 kg.

Table 1: Estimated effects*of cow's sire's APR on 305-day milk production for lactations from Holstein-Friesian cows by feeding system, adjusted for the cow's maternal grandsire's APR
(95% Confidence Interval)

MILK PRODUCTION VARIABLE	FEEDING SYSTEM				
	1. Low Bail	2. Mod-high Bail	3. PMR	4. Hybrid	5. TMR
Milk volume (l)	56.2 (40.9 to 71.5)	68.0 (60.4 to 75.6)	53.7 (39.8 to 67.7)	79.7 (58.8 to 100.6)	109.9 (75.1 to 144.8)
Fat yield (kg)	2.6 (2.0 to 3.2)	2.5 (2.2 to 2.8)	1.5 (1.0 to 2.0)	3.5 (2.7 to 4.3)	5.7 (4.4 to 7.1)
Protein yield (kg)	2.6 (2.1 to 3.1)	3.4 (3.2 to 3.6)	2.9 (2.5 to 3.4)	4.0 (3.3 to 4.6)	5.1 (4.0 to 6.2)

**Coefficients represent estimated change in milk production variable per 50 unit increase in the cow's sire's Australian Profit Ranking; coefficients were adjusted for age at calving; herd and cow within herd were fitted as random effects*

Figure 1 illustrates that for Holstein-Friesians in all five feeding systems, protein yield increases incrementally at about the same rate with an increase in the cow's sire's APR.

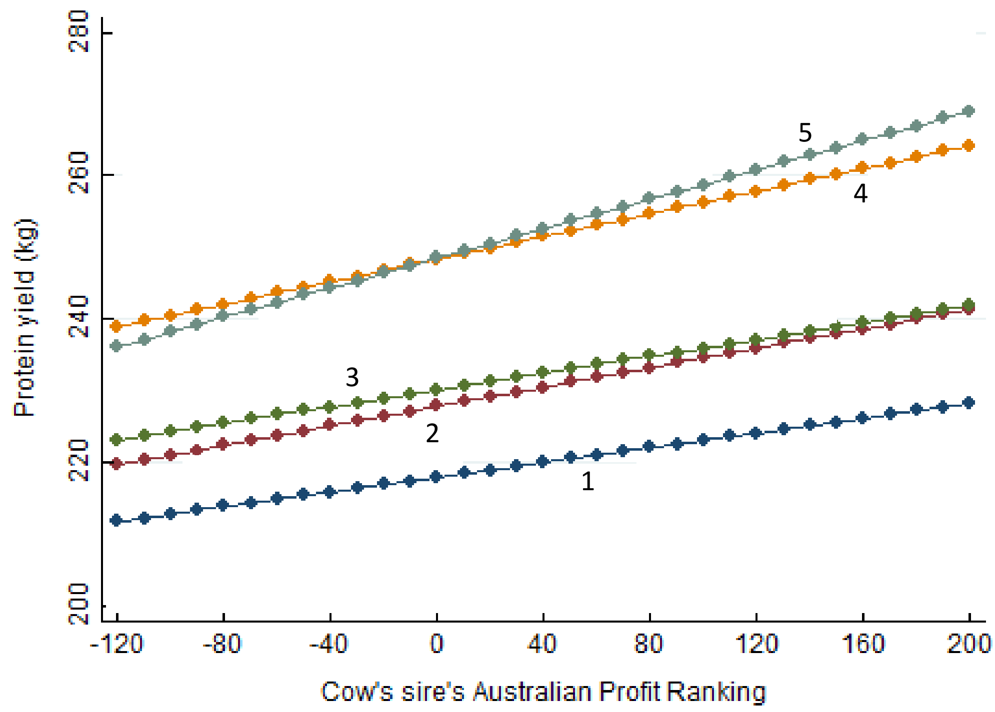

Figure 1: Predicted 305-day protein yields by cow's sire's APR for lactations from Holstein-Friesian cows by feeding system, adjusted for the cow's maternal grandsire's APR. Feeding systems are 1. Low Bail, 2. Mod-high bail , 3. PMR, 4. Hybrid and 5. TMR.

For Holstein-Friesian cows, effects of increases in ABV for milk volume, fat and protein yield were smallest in the Low Bail feeding system and largest in the TMR feeding system.

- For each 10 unit increase in the cow's ABV for milk, estimated milk volume increases per standard lactation were 7.2 litres in the Low Bail feeding system (system 1), just over 9 litres in the Moderate-high Bail, PMR and Hybrid feeding systems (systems 2 to 4) and 12.1 litres in the TMR feeding system (system 5).

- Estimated fat yield increases varied from 6.3 kg in the Low Bail feeding system to 11.8 kg in the TMR feeding system for every 10 unit increase in ABV for fat kg.

- Protein yield increase estimates varied from 7.6 kg in the Low Bail feeding system to 17.0 kg in the TMR feeding system for every 10 unit increase in ABV for protein kg.

For Jerseys, reliable comparisons were only possible across the Low Bail, Moderate-high Bail and PMR feeding systems (systems 1 to 3). As for Holstein-Friesians, the estimated effects of each 50 unit increase in the cow's sire's APR on milk volume, and fat and protein yield per standard lactation in the Low Bail, Moderate-high Bail and PMR feeding systems were positive (see Table 2). For most analyses, estimated increases were smaller for the Low Bail feeding system than for the Moderate-high Bail and PMR feeding systems.

Table 2: Estimated effects*of cow's sire's APR on 305-day milk production for lactations from Jersey cows by feeding system adjusted for the cow's maternal grandsire's APR

(95% Confidence Interval)

Milk production variable	Feeding system		
	1. Low Bail	2. Mod-high Bail	3. PMR
Milk volume (l)	42.1 (25.3 to 59.0)	55.9 (46.6 to 65.1)	49.5 (23.5 to 75.4)
Fat yield (kg)	2.6 (1.8 to 3.4)	3.4 (3.0 to 3.9)	3.7 (2.4 to 5.0)
Protein yield (kg)	2.0 (1.3 to 2.6)	2.8 (2.5 to 3.1)	2.9 (1.9 to 3.8)

**Coefficients represent estimated change in milk production variable per 50 unit increase in the cow's sire's Australian Profit Ranking; coefficients were adjusted for age at calving; herd and cow within herd were fitted as random effects*

In Jerseys, effects of increases in ABV for milk volume, fat and protein yield were also smaller for the Low Bail feeding system than for the Moderate-high Bail and PMR feeding systems.

For each 10 unit increase in the cow's ABV for milk:

- Estimated milk volume increases were 5 litres per standard lactation in the Low Bail feeding system, and 7 to 8 litres in the Moderate-high Bail and PMR feeding systems.
- Estimated fat yield increases varied from 6.0 kg per standard lactation in the Low Bail feeding system to 7.5 to 9.1 kg in the Moderate-high Bail and PMR feeding systems for every 10 unit increase in the cow's ABV for fat kg.
- Protein yield increase estimates varied from 5.3 kg per standard lactation in the Low Bail feeding system to 8.8 to 9.3 kg in the Moderate-high Bail and PMR feeding systems for every 10 unit increase in the cow's ABV for protein kg.

C. Effect of APR (and ABVs) on likelihood of cows lasting in the herd between feeding systems

Estimated effects of APR and ABVs for survival and fertility on the likelihood of re-calving by 20 months were estimated using odds ratios. For APR, in both breeds, most odds ratios were slightly above 1.0 with relatively narrow confidence intervals, even when adjusted for production. (See Figure 2 for Holstein-Friesians). This indicates that increases in APR do not markedly decrease the likelihood of re-calving by 20 months and in the Low Bail, Moderate-high Bail, PMR and Hybrid feeding systems (systems 1 to 4), may slightly *increase* the likelihood of re-calving by 20 months.

For Holstein-Friesian cows, all estimated effects of cow's ABVs for daughter fertility and survival were positive, indicating that the likelihood of re-calving by 20 months increases with these ABVs in all feeding systems. Estimated effects of cow's ABV for survival were smallest in the Low Bail feeding system (system 1) and largest in the TMR feeding system (system 5).

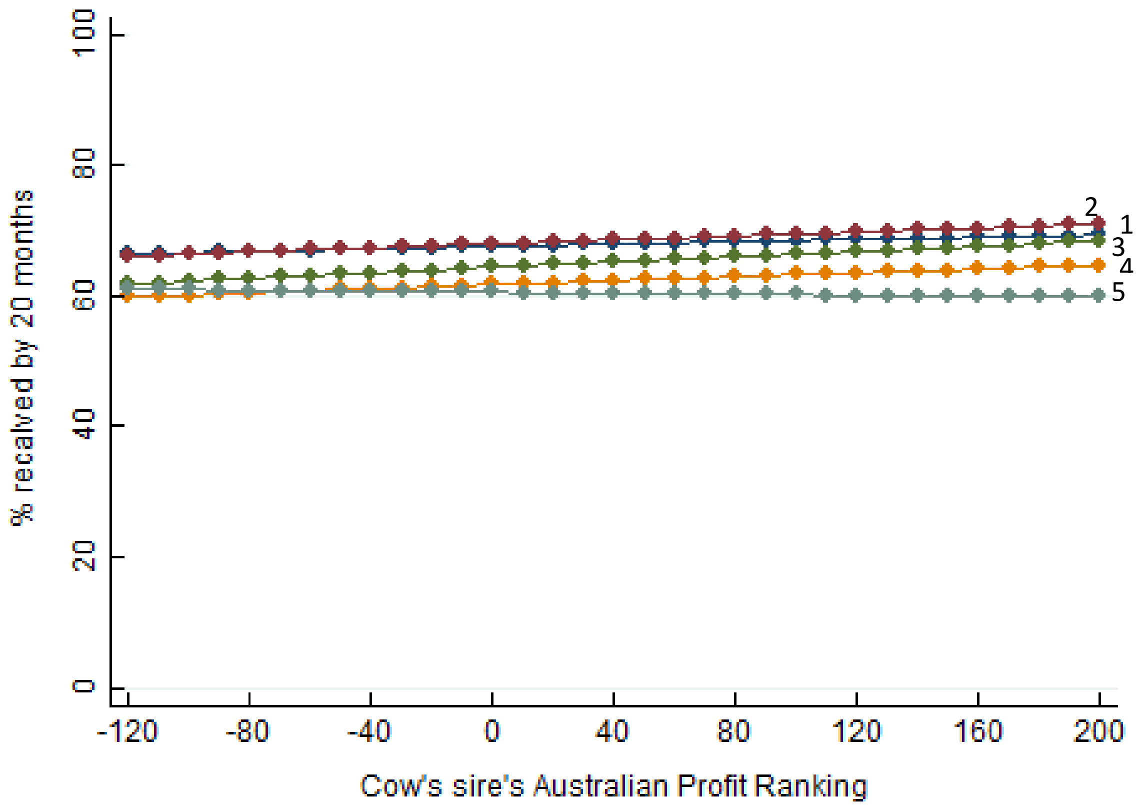

Figure 2: Predicted percentages of cows that re-calved by 20 months by cow's sire's APR for lactations from Holstein-Friesian cows by feeding system, adjusted for the cow's maternal grandsire's APR. Feeding systems are 1. Low Bail, 2. Mod-high Bail, 3. PMR, 4. Hybrid and 5. TMR.

For Jerseys, estimated effect of increases in cow's sires APR or cow's ABV for survival and fertility on the likelihood of re-calving by 20 months were relatively small.

The likelihood of short lactations (less than 120 days) were also assessed as a substantial proportion of cows with short lactations are likely to have had health problems post-calving that seriously affected milk production. For both Holstein-Friesian and Jersey cows, all odds ratios were close to 1.0 with relatively narrow confidence intervals, indicating that any effects of APR on the likelihood of short lactations are probably extremely small. There is some evidence for small reductions in the likelihood of short lactations as APR increases in some feeding systems. So higher APR cows certainly do not crash and burn.

SELECTING HIGH APR BULLS ISN'T DIFFICULT AND THEY DON'T NECESSARILY COST MORE

Selecting high APR bulls with confidence when choosing which semen to buy isn't difficult. Simply stick with the bulls in the ADHIS Good Bulls Guide's Profit list. These bulls typically have APRs that are at least \$150 to \$200 more profitable than average.

The semen of these bulls does not necessarily cost more than that of other bulls. ADHIS has compared recommended retail prices provided by semen suppliers for semen of Holstein bulls in the April 2013 Good Bulls Guide, grouped by APR rank (Top 50, 51st to 100th, 101st to 150th, 151st to 200th, 201st to 250th, 251st to 300th, and bulls ranked below 300th). As shown in Figure 3.

- The average recommended retail price per straw across the groups ranged from \$20 to \$28.
- On average, semen from bulls in the top 50 cost slightly less than that of the group of bulls ranked 51st to 100th.
- Semen from bulls within the top 50 group by APR varied widely, from \$14 to \$90 per straw.
- The average profit per cow per year was \$255 for bulls in the top 50, compared to \$124 for bulls ranked greater than 300th (a range of \$131). Yet the price per straw for bulls in the top 50 was only 15% more than that of bulls ranked below 300th (\$27.17 versus \$23.58).

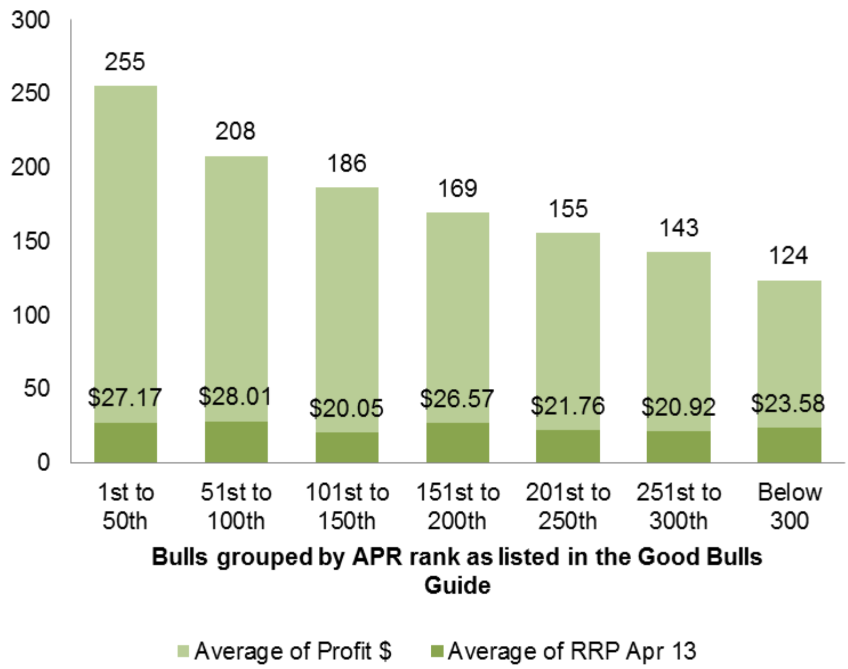

Figure 3: Average recommended retail price of Holstein bulls and their comparative profit

To download the latest edition of the full Good Bulls Guide, go to www.adhis.com.au

CONCLUSION

With the findings of the ADHIS *Feeding the Genes* study, dairy farmers can now be very confident they can achieve more with any feeding system by using better bred (high APR) bulls. Nutrition advisers can be confident in promoting the use of high APR bulls regardless of the feeding system being used, and the use of the Good Bulls Guide to select bulls that suit each client's production system and goals.

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- *Feeding the Genes* project reference group members: Michelle Axford, Steve Little, Tim Harrington, Neil Moss, Paul Douglas, Daniel Abernethy, Jennie Pryce, Mike Goddard and Gert Nieuwhof.

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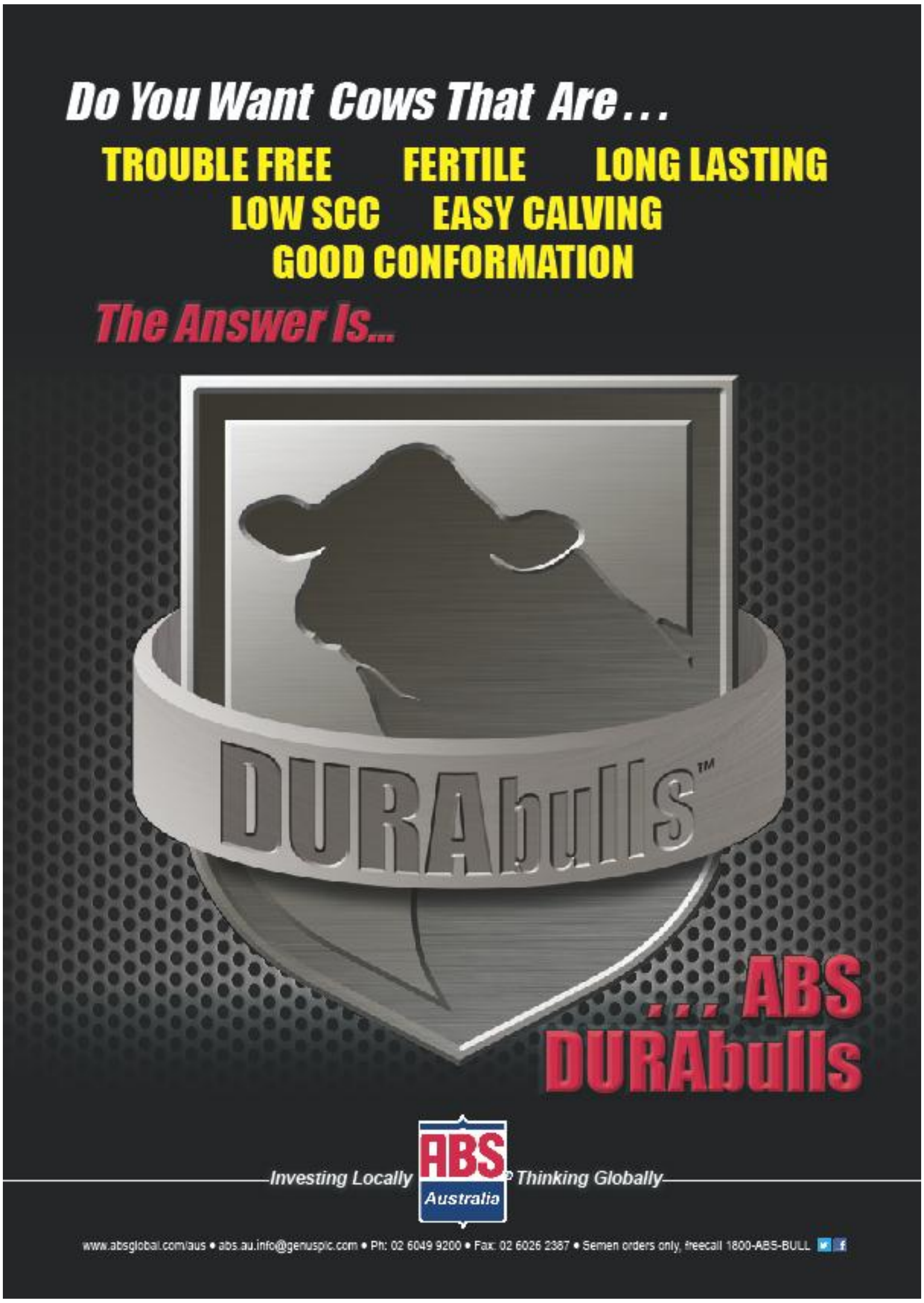
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What are we feeding to our cows?

C. Clark

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- Cows within the same herd access pasture of vastly different nutritive value.
- Individual cows in automatic milking systems access pasture of inconsistent nutritive value across and between days.
- Opportunities exist to capitalise on this variability by controlling feed inputs.

INTRODUCTION

Automatic milking systems (AMS) require cow traffic (the voluntary movement of cattle around a farm) to enable cows to be milked. This motivation for cow traffic is primarily created by offering incentives in the form of feed. Grain offered at the milking facility is the primary incentive for cow traffic in 'housed' AMS systems in the Northern Hemisphere due to the preference for grain over the remainder of the mixed ration which is typically offered on a feed pad close by. In contrast, Australia's pasture-based AMS cows are motivated to access both grain at the milking facility and fresh allocations of pasture. In this regard, it is common practice to split daily allocations of pasture on AMS farms into three distinct allocations (Jago *et al.*, 2002) to encourage voluntary cow movement throughout the 24 hours of a day.

As opposed to conventional milking systems (CMS), AMS cows typically move from depleted to fresh allocations of pasture in small groups, or individually, at different times throughout the 24 hours of a day. Automatic milking system farms typically split their daily pasture allocation into two or three breaks and as a result, individual cows may access the same allocation of pasture up to 12 hours apart. Thus, the structure of AMS cow movement is in stark contrast to conventional milking systems (CMS) where cows are typically moved as an entire herd and access a new allocation of pasture commonly within a few hours of each other. From a cow's perspective, the first cow arriving at a new allocation of pasture, whether it be on a CMS or AMS farm, is offered an ad-libitum allowance of pasture which is progressively depleted as more cows arrive after they are milked. If this depletion of pasture were rapid whilst cows continue to access a pasture allocation, then there may be vast differences in the nutritive value (crude protein, fibre etc.) of pasture offered to cows within the same herd. In addition, if each cow varied their timing of access consuming an inconsistent diet in terms of nutritive value, then this may create an unstable rumen environment compromising levels of feed conversion efficiency and milk production.

This manuscript reviews the depletion of pasture and associated nutritive value that differing cows within the same herd access. Also, the consistency with which dairy cows access pasture of varying levels of depletion will be provided together with the opportunities for both AMS and CMS farms to control feed inputs to capitalise on this variability.

THE DEPLETION OF PASTURE

Automatic milking systems

Data taken from FutureDairy's Camden AMS farm (N. Lyons unpub. data) shows the rate of pasture depletion when an allocation of pasture was accessed by cows over 12 hours (Figure 1). At 23 hours after the allocation was offered, the remaining cows in the paddock were fetched to the milking facility. These data show pasture allowance to ground level to be depleted by approximately 40% over the time that individual cows accessed the same allocation (up to 12 hours paddock time).

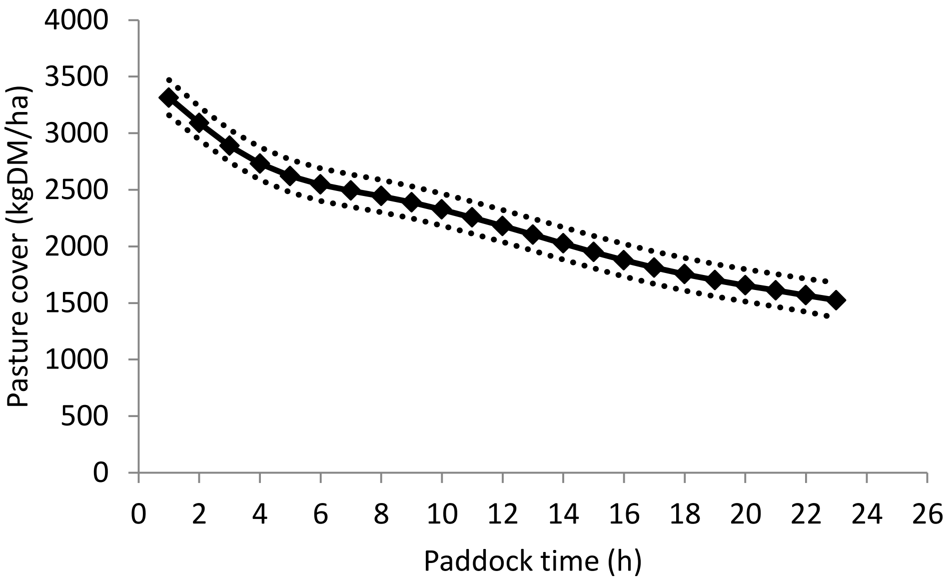

Figure 1: The depletion of pasture cover in a pasture-based automatic milking system fitted using a spline smoothing mixed model function. Dashed lines represent mean ± SE. (Source: N.Lyons, unpub. data).

Conventional Milking Systems

Given that a milking session in CMS typically lasts for 2-3 hours, the approximate maximum time from the first to the last cow entering an allocation of pasture will be approximately 2-3 hours. Surprisingly, there is very little work on the depletion of pasture for CMS farms from the time that the first cows arrive until the cows are collected for the next milking. Data from Argentina (S. Garcia unpub. data) and from Australia (B. Fulkerson pers. comm.) suggest that pasture allowance to ground level is depleted by 40% during the time that CMS cows access a pasture allocation over 2-3 hours.

THE NUTRITIVE VALUE OF DEPLETED PASTURE

As strip-grazed cattle offered a homogenous sward typically ingest pasture in successive layers (Wade and Carvalho, 2000), the quality of the diet consumed typically decreases with increasing grazing severity as there is less green leaf and more dead material in the lower stratum or layers (Chacon and Stobbs, 1976). Data taken from Delagarde *et al.* (2000), shown in Table 1, highlights the vast difference in nutritive value through the successive layers of perennial ryegrass. If 40% of pasture allowance to ground level is removed in both CMS and AMS farms whilst cows access an allocation of pasture, and the sward is similar in composition to that reported by Delagarde *et al.* (2000), then those cows arriving first to an allocation of pasture are consuming pasture with 239g crude protein and 412g neutral detergent fibre per kg DM. In contrast, the last cows accessing the same allocation would be offered low crude protein (155g/kg) and high neutral detergent fibre (566g/kg) feed. The pasture that these last cows access would limit milk production to <20L/cow/day. If the order of pasture access for these cows varied within, and between, days then fluctuations in the nutritive value of diet may be buffered in the rumen and by the cow itself, enabling increased milk production. However, solving this issue through fluctuations in the nutritive value of the diet may reduce the stability of the rumen environment and associated digestion of feed.

Table 1: Total biomass, crude protein (CP) and neutral detergent fibre (NDF) (g/kgDM) for each fraction of perennial ryegrass above ground level (Source: Delagarde *et al.* (2000)).

Fraction (cm)	Total biomass in fraction (%)	CP (g/kgDM)	NDF (g/kgDM)
>15	22	239	421
10 to 15	15	193	497
5 to 10	24	155	566
0 to 5	39	133	675

THE CONSISTENCY OF PASTURE ACCESSED

Automatic milking systems

Across 23 days of intensive data collection at the Camden AMS research farm, cows generally accessed an inconsistent level of pasture depletion (nutritive value). In this regard, 55 out of the 170 cows accessed fresh pasture approximately half (50-60%) of the time (Figure 2). There were, however, a small proportion of cows (<10% of the herd) that consistently accessed either fresh or stale pasture suggesting that there are cows within AMS herds that have learnt to time their movement based on the time that a pasture allocation opens.

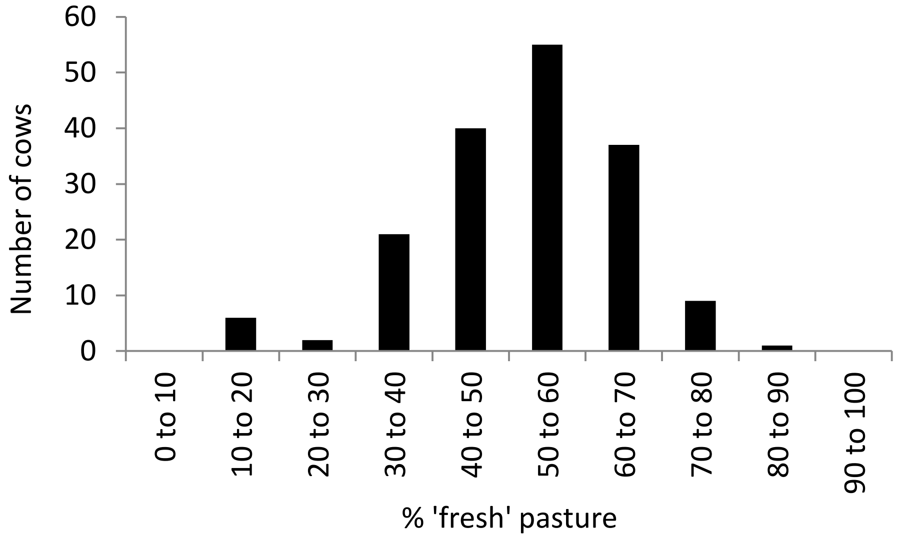

Figure 2: Number of cows at the Camden AMS farm accessing a 'fresh' state of pasture

Conventional milking systems

Cows in the CMS study of Botheras (2006) had a consistent milking order both within and between days, reinforcing the observations of many Australian dairy farmers who would know the first and last cows going through the dairy if not by name, then at least by nature and appearance. The reasoning for this consistency is, in part, due to the dominance structure of CMS dairy herds with mid-dominant animals typically leading, high ranking individuals occupying the middle, and subordinates being found at the rear of a herd (Arave and Albright, 1981).

CONTROLLING FEED INPUTS TO CAPTIALISE ON VARIABILITY

This manuscript has highlighted the variability in pasture nutritive value that is offered to AMS and CMS dairy cows within the same herd. As a summary so far:

i) Pasture is depleted in both AMS and CMS by approximately 40% to ground level whilst cows continue to gain access to any given allocation.

ii) Given point i), data from Delagarde *et al.* (2000) suggest that individual cows within both AMS and CMS herds access pasture of a vastly different nutritive value.

iii) CMS cows tend to access a consistent, and AMS cows access an inconsistent nutritive value pasture.

To capitalise on this variability, future dairy systems will increasingly use differential feeding to target individual cows based on a predicted response. There are numerous strategies/technologies currently used to differentially feed cows such as feeding to yield, stepped feeding and component feeding of supplements. In this regard, FutureDairy work (Garcia *et al.*, 2007) showed CMS milksolids yield to increase by ~7% in the short term by allocating grain-based concentrate (GBC) to dairy cows based on individual cow requirements, rather than on a herd basis at a fixed rate. Given the findings of the current manuscript, future CMS research should evaluate the cost/benefit of varying the protein to energy ratio of GBC as milking progresses to coincide with the decline in the crude protein content of pasture, particularly at times when the crude protein level of pasture is reduced. In essence, this differential feeding would take the next step from the work of Garcia *et al.* (2007), and match energetic and protein requirements to the predicted pasture nutritive value that each cow in the herd accesses.

Alongside the level of depletion, the consistency that cows access certain levels of depletion may be another variable on which to base differential feeding decisions on AMS farms. Recent work by the FutureDairy team (Kaur *et al.*, 2013) showed that the consistency by which cows access fresh and depleted pasture affected the milk production response to grain-based concentrate (GBC) (Table 2). Cows were offered either consistent fresh or depleted pasture or inconsistent alternate allocations of either fresh or depleted pasture after each milking. There was no increase in milk production above a GBC level of 5kg DM/cow/day for both inconsistent treatments. However, for one of these inconsistent treatments, milk production levels were similar across all GBC levels. These findings suggest that the rumen environment for AMS cows accessing inconsistent levels of pasture depletion (i.e. Fresh, Depleted or Depleted, Fresh), and high levels of concentrate (>5kg DM/cow/day) is unstable leading potentially to reduced conversion of GBC into milk and/or increased levels of substitution.

Table 2: Milk yield (L/d) of cows offered different pasture states[1] and grain-based concentrate allocations[2]

Pasture state (AM, PM)	Grain-based concentrate (kg DM/cow/day)		
	2.7	5.4	8.1
Fresh, Fresh (L/cow/day)	22.7[a]	22.9[a]	25.5[b]
Depleted, Depleted (L/cow/day)	20.1[a]	21.5[a]	24.9[b]
Fresh, Depleted (L/cow/day)	20.8	22.5	22.6
Depleted, Fresh (L/cow/day)	20.1[a]	23.0[b]	23.7[bc]

[1]*fresh kikuyu (60kgDM/cow/day to ground level), depleted kikuyu (40kgDM/cow/day to ground level)*

[2]*Superscripts denote significantly different means within* row

Using technology to aid in management decisions

The current work has highlighted yet more information that could be used to capitalise on the variability that occurs both between cows and the pasture that they access. Given the numerous differential feeding strategies on offer, technology has a role to pull these strategies together into an overarching management system to aid on-farm decision making. As discussed at last year's Symposium (Clark, 2012) recent research (Romera *et al.*, 2010) has highlighted the ability to fit empirical parameters to observations to 'train' a model to increase the accuracy of individual paddock pasture growth predictions. In effect, this model (PGSUS) learned from the past to better predict the future. Based on the current findings, and reviewed work within this manuscript, a similar method is required to differentially feed cows based on an expected (learnt) efficiency that purchased feed is converted to a saleable product. This would be a logical progression from current fixed rate feeding or the independent use of numerous aforementioned strategies/technologies. In theory, feed inputs could be optimised based on expected milk production, animal welfare (BCS etc) and/or profit.

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Preparing for the Journey Ahead

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- Start with clear goals of what you want to achieve through transition, and ensure the whole team are on board with these
- Assess potential risks and challenges which could stop you achieving these goals and put plans in place to mitigate these risks
- Select the tools most appropriate for your farm situation, and where possible plan for prevention rather than cure
- Ask the cows for feedback – look at body condition score, rumen fill, cud chewing activity, dung score and general behaviour

GOALS

It all starts with a goal. Whether that goal is to finish a solo sailing race across the Tasman or to achieve record milk production, it needs to be a SMART goal. Specific, measurable, achievable, realistic and time defined. It is also important that everyone involved in reaching the goal believes that it is achievable.

The big goal can appear more reachable when it is broken into smaller goals. For example, a big step towards making it across the Tasman is having a well prepared yacht, and a key step towards record production is a well prepared (well transitioned) herd of cows.

The transition period is defined as the 4 weeks either side of calving, and management of cows through this period has a major influence on production and fertility in the subsequent lactation. In the same way that my chance of successfully crossing the Tasman alone in a small yacht was largely determined before I crossed the start line, by the time a cow calves good transition management will have gone a long way towards ensuring production targets are met.

Four key goals for successful transition management are minimising rumen disruption, safeguarding against macro-mineral deficiencies, avoiding fat mobilisation disorders and reducing immune suppression. These goals can be further broken down within these key areas. For example, Table 1. shows realistic targets for some of the health challenges cows face around calving time.

Table 1:

Health challenge	Target
Milk fever	1%
Clinical ketosis	< 1%
Abomasal displacements	< 1%
Clinical mastitis	< 5 cases/100 cows/first 30 days
Lameness	< 2% with > score 2
Hypomagnesaemia	0%
Retained placenta > 24 hours	< 4%
Vaginal discharge after 14 days	< 3%
Calvings requiring assistance	< 2%
Clinical acidosis	0%

Source: Dairy Australia

PLANNING AND PREPARATION

Risk assessment

Planning starts with assessing the likely risks and challenges that could be faced. In every venture there are always risks. These can be divided into external risks (those outside our control) and internal risks – those where we have influence. Examples of external risks include weather events, power cuts and disease outbreaks. For these risks we need strategies in place to mitigate the risk. When sailing, storms and rogue waves are external risks. In farming too, weather is a major factor. In sailing there is a saying 'You can't control the wind but you can control the set of your sails'. In farming maybe "You can't control the weather but you can control the size of your forage stocks" would be comparable?

We can't control whether we have droughts, floods or power cuts, but we can have a contingency plan in place such as extra forage or a generator. During transition, cows are more vulnerable than ever to a sudden unexpected lack of feed, extreme wet and cold, or a disease challenge such as salmonella. This makes contingency plans important to ensure targets are achieved whatever extreme weather or other unexpected events are thrown at you.

For internal risks, we have more control and can put plans in place to reduce the likelihood of them occurring. The fence at the top of the cliff is so much better than the ambulance at the bottom, whether the risk is falling overboard mid-Tasman or losing cows with milk fever. "How am I going to avoid falling overboard?" comes before "How am I going to survive when I do?" "How am I going to ensure cows don't get milk fever?" is the priority question, not "How many bottles will I need to get them up when they go down?"

For transition cows, internal risks include ketosis, rumen acidosis, displaced abomasum, milk fever, hypomagnesaemia, retained placenta, metritis, calving difficulties, lameness and unexpected death. Constructing good sound fences for all these challenges will help ensure a smooth, incident free transition and often several fence posts are needed. For example, in preventing the risk of ketosis, fence posts could include ensuring cows are at target body condition score (BCS) when they enter the springer mob, having a good balanced diet for springers which enhances rumen adaptation, optimising feed intake pre- and post-calving and safe guarding against mycotoxins which could compromise liver function. Many of the above challenges are inter-related so a good fence for one will often help reduce the risk of another occurring.

Appropriate tools

Plans need to be comprehensive – look at every tool in the tool box and select those most appropriate for your situation. Solely relying on a low calcium diet pre-calving may not be enough to prevent milk fever. Magnesium is equally important and sometimes a high dietary phosphorus level can be an issue. Assess the dietary cation anion difference (DCAD) of the springer diet and consider whether you need to use anionic salts where appropriate.

Another tool used by some NZ dairy farmers is a 'start up' drench (usually molasses, mono propylene glycol, protected fat and minerals). Cows are given 1 litre of this drench soon after calving to reduce the risk of both milk fever and ketosis. On larger farms where it isn't practical to drench every cow, this is restricted to the most at risk cows (e.g. those with milk fever history, twins or difficult calvings, older cows or the highest yielders).

The more tools in the tool box, the more chance of having the ones you need. I learnt a lot of useful solutions to potential challenges by reading books on sailing and listening to experienced sailors. I went out of my way to track down people with relevant experience and plucked up the courage to speak to complete strangers who were nearly always ready to help once they knew what I wanted to know and why. You all have a wonderful opportunity at symposiums such as this to learn from your fellow farmers as well as from the speakers. Neighbours and local vets and advisers who have been in your area longer than you are also a valuable source of information.

Calculating value

When considering different tools to help you achieve your goals, look at the value of using that tool in your situation. What is the cost and what is the likely return? During the transition period, the likely return can be greater than at other stages of lactation for the same cost. One example would be forage quality. As cows approach calving, appetite drops, and it takes time to recover after calving. Also during transition cows are more vulnerable to the harmful effects of mycotoxins. Spending more on forage conservation and storage to ensure good palatability with no risk of mould or spoilage has more value when that forage is destined for transition cows. Another example would be the value of a more expensive, better quality trace mineral supplement. We know immunity drops off in the last 3 weeks before calving and 80% of disease costs occur in the first 4 weeks after calving. Therefore anything that helps boost immunity, such as proven organic selenium or vitamin E, is going to give a greater payback when fed to cows during transition than it will if fed during mid-lactation.

Checks and double checks

Once plans are in place, there need to be systems to ensure they are followed through. I discovered a 'Black Box Theory' in a sailing book by John Vigour which I think is equally applicable in farming. He said to imagine a black box fixed at the base of the mast (yours could be in the dairy). Planning, preparation, practice and routine checks and double checks all put deposits in the imaginary black box. Withdrawals are made every time you encounter difficult conditions such as adverse weather. The box needs regular topping up!

It is noticeable in sailing that those who keep their yachts well maintained and make regular checks during a voyage are far more likely to reach their destination intact, whatever the weather does. Similarly, I am sure you can think of some 'lucky' farmers who put a lot of time and effort into planning, preparation and routine checking and who achieve above average results. 'Lucky' is a term used by some to describe people who have in reality made their own 'luck' by filling up their black box.

In farming sometimes the best laid plans do not come to fruition because they are not carried out correctly. A system of checks will ensure any discrepancies are picked up early before much damage is done. If a load of feed should last a month and the bin is half empty at the end of the first week something is wrong. Looking at the bin sight glass regularly will pick this up. I had a laminated checklist to use in the Tasman Sea which helped make sure I didn't miss any of the daily checks I needed to do, regardless of how tired I was.

PEOPLE

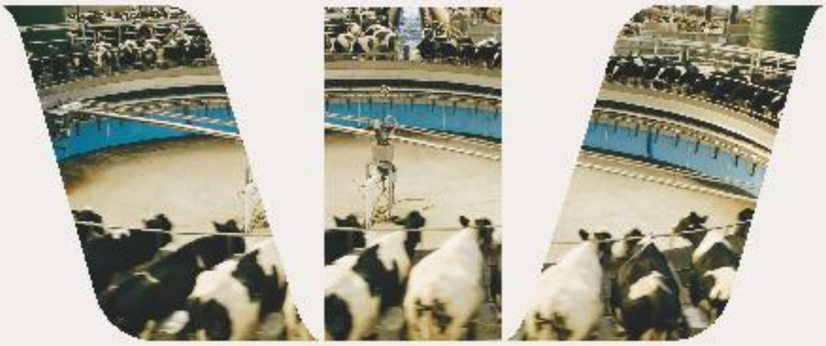
Although the Solo Trans-Tasman is a single handed race, I would never have completed on my own. The team of people that supported me were crucial to my success. One key ingredient was getting people to work together to reap the synergistic effect. For example, I had the sail maker, rigger and furler supplier all meet together on Wishbone to discuss how best to set up a code zero sail for her. They bounced ideas around and drew on each other's experience to come up with the best possible solution. I would equate this for example to having your nutritionist, veterinarian and milking machine servicer all on farm together to discuss the best solution to a mastitis challenge.

One thing I didn't have was a crew, and although this left me to do everything myself it also removed a whole section of potential challenges. Most dairy farms have other family members and staff, and these people will have a big influence on whether your goals are reached. If the whole team are on board with the farm goals, see them as achievable and are committed to doing what it takes to get there, you are already much closer to reaching you goals.

At busy times like calving, it is easy for people to get tired and dehydrated, and to eat snack food because they don't have time to cook a balanced meal. Lack of sleep reduces your ability to make sound decisions, as has been demonstrated by many single handed sailors, so it is important to have a good roster to ensure everyone gets the sleep they need – 5 hours per night is an absolute minimum. Good nutrition is just as important for people as it is for the cows, and someone working hard through calving is doing the equivalent of an endurance sportsman. Stocking the freezer with wholesome meals before calving starts can be just as important as ordering in the feed for the cows.

FEEDBACK

As I sailed across the Tasman, I used the 'tell tails' (short pieces of wool) on my sails to let me know if my sail trim was optimum or whether I should make adjustments to improve my yacht's performance. Similarly, the cows are giving you signals to tell you how well you are doing and whether there is scope for improvement. Body condition score is an important signal – both current score and rate of change. Rumen scoring is a measure of rumen fill and a check on whether the cows are being fully fed. Assessing cud chewing activity indicates whether there is the right amount of effective fibre in the diet. Inspecting the dung tells you a lot about the balance of the diet, cow health and sometimes the effectiveness of grain processing. Finally, observing thirsty cows hanging round an empty water trough is a clear signal that prompt action is needed!



Silvermere Holsteins: Transition Management

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- Transition failures compromise cow health, production, reproduction and welfare
- Implementing a transition monitoring program is inexpensive
- Transition monitors facilitate rapid detection of impending failure
- Transition monitors help to trouble shoot transition problems
- Monitoring needs to be ongoing as the transition may be positively or negatively impacted by changes in forages and other feed ingredients.

DAIRY BACKGROUND

Callara is a family owned freestall dairy milking 300 cows with a year round calving pattern. Average daily milk production per cow is ~ 40 litres (3.5% fat, 3.15 % protein). Approximately 30 cows calve per month. The objective is to maintain an average days in milk around 175 days. Experience has highlighted the importance of the transition period on cow health, milk production and reproductive performance. This presentation will illustrate one of these scenarios.

Features of the transition management program include.

1. Pregnancy diagnosis between 32 – 46 days gestation to establish an accurate conception date to facilitate the timing of dry off and introduction to the transition ration.
2. Early pregnancy diagnosis also allows early enrolment in an ovsync program for problem breeders.
3. Cows are introduced to an anionic transition ration 21-28 days prior to calving (weekly).
4. Feed bunk and freestall space for transition cows is adjusted according to the number of cows in the pen to avoid overcrowding.

5. A nutritionist formulates rations for all classes of stock on the farm.

Cow health, reproduction and production records are maintained in the DeLaval Alpro software package. Feed budgeting and daily ration details are maintained in Excel along with a diary of significant events (changes in forage sources etc. for trouble shooting). A number of variables are monitored to evaluate the effectiveness of the transition program. These monitors include.

1. Dry matter intake

2. Incidence of fresh cow disease

3. Milk production and milk components

4. Body condition score

5. Fresh cow beta hydroxyl butyrate

6. Close up urine pH

7. Mortality/Culling during the first 60 days of lactation.

Originally cows were grazed and maintained in dry lots with the bulk of feed delivered on a covered feedpad. In 2011 the covered feedpad was converted to a freestall barn for lactating and transition cows. Drivers for this change include:

- To increase DMI by keeping the cows close to feed at all times

- To combat heat stress effectively

- To overcome feet problems caused by cows standing too long on concrete, particularly in summer

- To improve cow comfort with less stress in a clean, dry environment

- To reduce environmental mastitis

- To be able to closely monitor transition and calving cows

- To provide a clean and convenient calving environment

While milk production has historically been maintained between 33 – 36 litres per cow per day fluctuations in fresh cow performance have negatively impacted cow health, production and reproductive performance. The goal is to ensure a consistent and smooth transition from pre calving to peak production with good reproduction performance.

This will be achieved through environmental management (freestalls and calving pen) and through better forage management. Forage management involves:

- Accurate preseason planning for crop varieties and areas to be grown that will fill feed requirements.

- Implementing high quality harvesting and ensiling or storage techniques with particular attention to silage face management and feed storage hygiene.

- Providing a consistent and high quality TMR at all times.

During the latter half of 2012 the herd experienced problems with transition cows that was manifested by a high incidence of displaced abomasums, increased culling, reduced milk production and compromised reproductive performance.

TRANSITION COW URINE PH

One of the objectives of feeding a transition diet is to prevent milk fever. The inclusion of anionic salts in the ration induces a slight metabolic acidosis which is reflected by urine acidification. Cows normally have a urine pH of 8 – 8.5. Feeding an anionic diet drops the urine pH to around 6.5. While a low urine pH is not a definitive assessment of the effectiveness of feeding an anionic ration it is a useful monitor of change on a farm, for example following a change in forage.

In November 2012 the urine pH of transition cows increased. This was associated with a change in forage and a change in the transition mineral. This was subsequently associated with an increase in ketosis in fresh cows, displaced abomasums and increased early lactation culling.

DRY MATTER INTAKE

Transition cows are fed a dry premix transition ration that contains a concentrate premix and cereal hays. Special care is taken to never allow any contaminated feed to be fed to these cows and stale or wet feed promptly removed and replaced. The cows are closely monitored to observe feed intakes, headlock and freestall usage with special attention given to training heifers.

INCIDENCE OF FRESH COW DISEASE

The incidences of fresh cow diseases are monitored as a percentage of cows calving each month that are affected with common fresh cow disorders. Because the number of animals calving each month is relatively small the incidence appears quite volatile. When the denominator is small a small number of cases can cause a relatively large shift in percentage. Despite this limitation it is evident in Figure 1 that the incidence of displaced abomasums was high for the latter half of 2012 and was associated with a high incidence of milk fever reflecting a failure of the transition ration.

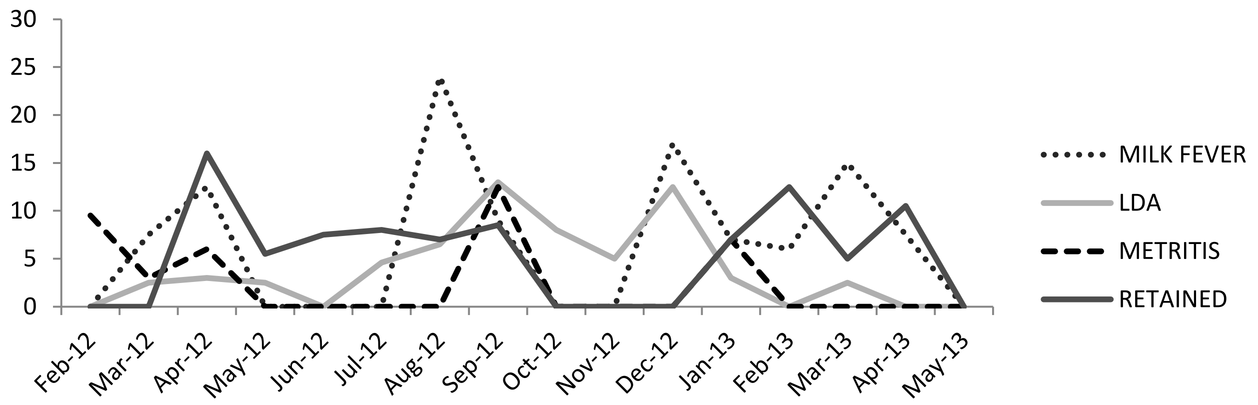


Figure 1: Monthly incidence of transition related diseases

MILK PRODUCTION AND MILK COMPONENTS

When milk production and milk components are analysed according to the stage of lactation it is possible to gain an insight to energy balance through the transition period. In particular milk fat percentage during the first 30 days of lactation (Figure 2a) and milk production during early lactation. Milk protein percentage is also useful for monitoring energy balance during peak lactation.

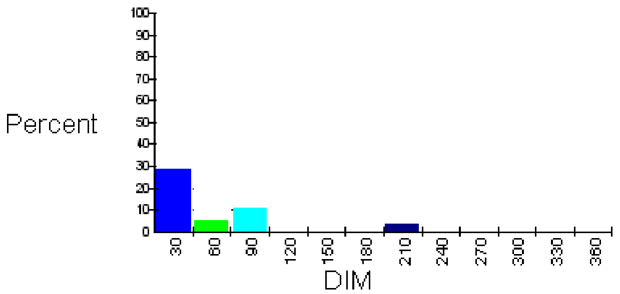


Figure 2a: When greater than 10% of cows in early lactation have a fat test > 5% it suggests negative energy balance in the transition period. This typically reflects negative energy balance starting prior to calving.

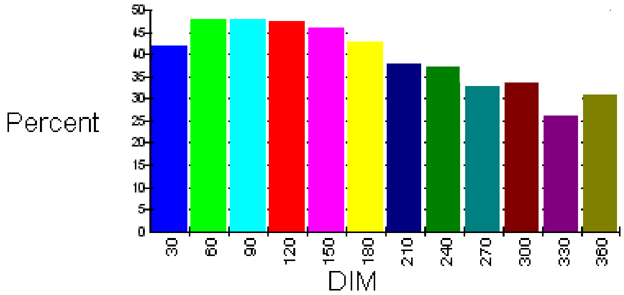


Figure 2b: Poor transition outcomes are often reflected by poor milk production during early lactation. Plotting milk production by days in milk is one way to look at this. Alternatively one can examine the proportion of cows producing less than 20 litres in the first 30 days of lactation.

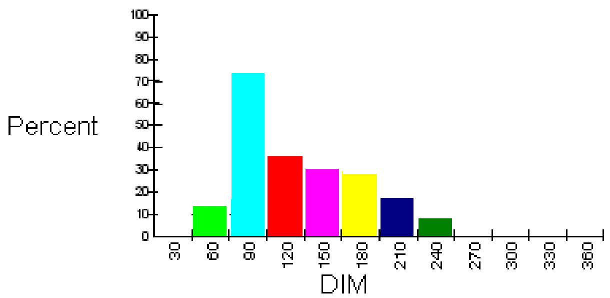


Figure 2c: A simple method of monitoring energy balance during early lactation is to monitor the percentage of cows with a milk protein percentage less than 2.9%. In this example it is evident that cows are running out of energy during peak lactation. This is likely to compromise conception rates in these cows.

BODY CONDITION SCORE

Ideally cows should calve in a condition score around 3.25 on a scale of 1 – 5. Excessive loss of body condition during early lactation reflects negative energy balance. Condition score is monitored to assess energy balance and to avoid over conditioned cows which are more likely to experience transition related disease. There is an interaction between reproductive performance and nutritional management. Poor reproductive performance leads to long lactations and potentially over conditioned cows.

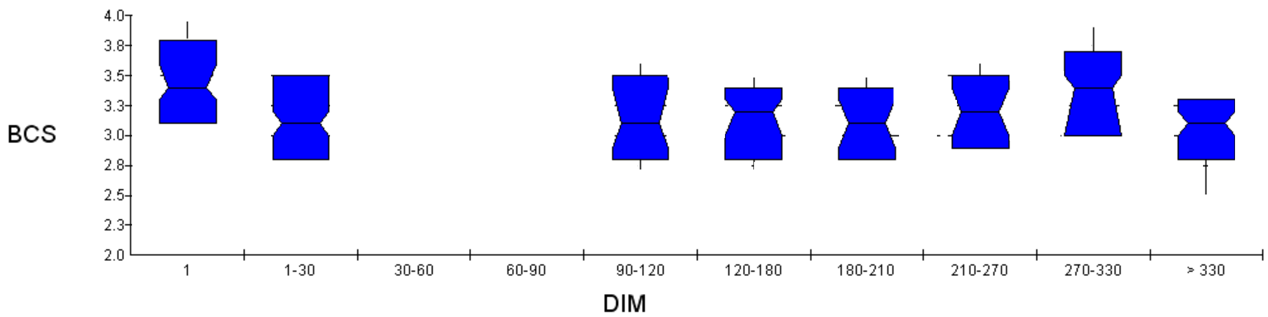
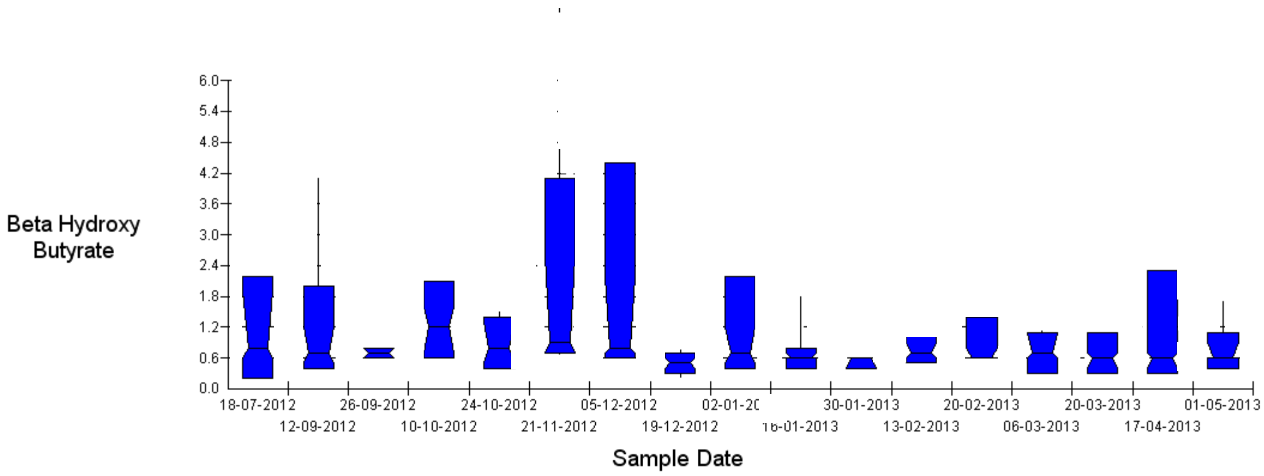


Figure 3: DIM 1 are cows in the pre-calving pen. The average condition score of the pre-calving cows is on average heavier than the target 3.25. The over conditioned cows will have a higher risk of disease post calving.

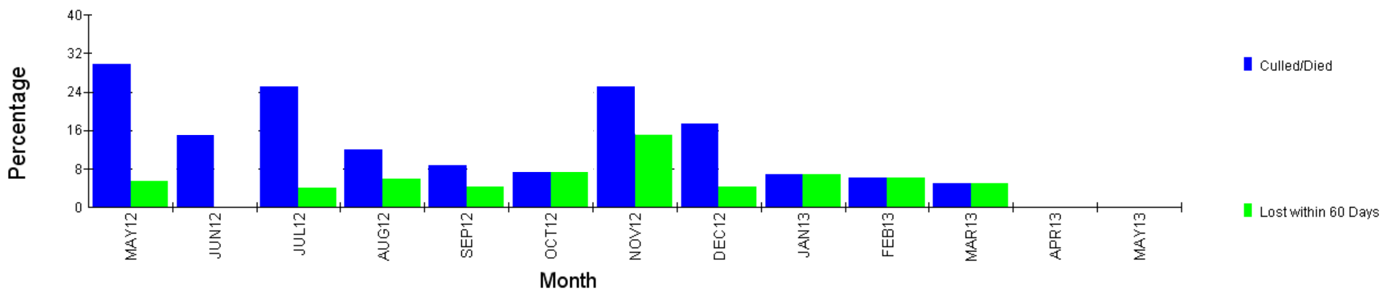
FRESH COW BETA HYDROXY BUTYRATE

Research has demonstrated that fresh cows with a beta hydroxy butyrate (ketones) concentration greater than 1.2 have an increased risk of disease. Between July and December 2012 the proportion of cows with high ketones exceeded 10%. This coincided with an increased incidence of displaced abomasums.



COW MORTALITY/CULLING DURING EARLY LACTATION

High mortality/culling during the first 60 days of lactation reflects transition failure. The target is to keep cow attrition during the first 60 days less than 8%. Note the high cull rates in November and December. This coincided with elevated ketones, high urine pH and a high incidence of displaced abomasums.



THE IMPORTANCE OF MONITORING

Establishing monitors for the transition period does not prevent transition failures however it is useful for early detection of failure, problem solving and evaluating the effectiveness of interventions. Through monitoring transition cows during the past 2-3 years some transition problems have been highlighted. These include:

- Contaminated feed in feed troughs affecting intake (pre freestalls)
- An ingredient missing in transition premix (causing DA's and poor repro performance)
- Body condition score to high or low (causing ketosis)

- Feed sorting due to inadequate mixing and chop length (causing milk fever and DA's)

CONCLUSION

Transition failures are costly. The challenge is to deliver consistent performance over time with changing environmental conditions, feed ingredients and personnel. Establishing a monitoring program helps to keep a focus on meeting the cows need and is useful for trouble shooting problems should they arise.

Managing tiered milk production - making rational decisions in irrational times

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- The business owner and farm adviser worked to develop a plan to minimise losses under 13c tier 2 milk prices
- Rapid restructuring of the herd improved management and labour efficiency and optimised feed conversion efficiency
- Continued investment in pastures and concentrate manipulation helped maximise milk quality increased the proportion of milk sourced from home grown feed and reduced purchased feed costs
- Decision making focused on both short term cash-flow and long term business and wealth objectives
- Communication with peers, suppliers and staff was important
- Lessons were learnt that would be useful under more sustainable trading conditions

BACKGROUND

Reversion to tiered milk pricing in a large sector of the NSW and Queensland milk markets has provided significant financial and emotional challenges to dairy farmers in those regions. Businesses were given strong signals to modernise and expand in the post quota period running up to the GFC and many had done so. This development had in many cases been financially facilitated by the proceeds from co-operative share floats. Growth had also been assisted by significant borrowings from banks and other financial institutions lending against both increased land values and improved dairy cash flows. Milk processing companies promoted growth and expansion with incentive payments for new milk produced in excess of previous year's production.

Farm cash flows did improve but so did their risk profile. A combination of rationalisation and management decisions in the processing sector, aggressive pricing strategies from supermarkets and interactions and exposure to the world dairy market and high Australian dollar in the post GFC environment resulted in the imposition of processor regulated "quota", based on historical rather than current production. This had a devastating effect on many dairy business and farm families. This has flowed through into the service sector and communities that co-exist with these farms.

With the last 12 months seeing announcement of tier 2 prices from some processors that were significantly lower than the variable cost of milk production, farmers have had to make decisions that often defy the ecology of the milk production system, erode wealth and in many cases, work in what appears to be direct opposition to much of the learning and progress that dairy businesses have enthusiastically embraced in recent years.

As advisers, there has been an acute need to assist farmers in rational decision making in an irrational period. The short and long term cash flow and wealth implications of all farm decisions have required close scrutiny and there has been a need to focus on both the micro and the macro-bigger picture with all advice. Future price and supply uncertainty has made both advice delivery and uptake extremely challenging. In some cases, farms have been placed in unviable positions by these pricing changes and a series of exits from the industry has ensued. Debt facilitated property acquisitions, investment on farm infrastructure and family succession planning, all critical components of normal business development, have all contributed to increased leveraging and risk. In other situations farmers have responded to the signals and voluntarily taken the decision to exit. However, the majority of dairy farmers have chosen to continue farming.

Interactions between consultants and advisers and their clients are often challenging and the current environment has put many to the test. Advisers get to sit outside of the business and look in. They can review the numbers on paper and present the strategies and theory to their clients with all the best intentions, analysis and modelling behind it. Ultimately however, farmers need to live and execute the advice and are the ones who have to manage the realities of cash-flow constraints. Increased government and processor regulation, tightening access to credit and the challenges of being an employer add greatly to farmer's stress, fatigue and frustration.

Farmers are patently aware that they have been forced to make short term decisions that are detrimental to their long term income and wealth, as well as the health and welfare of the herds, properties and people they manage or live with. The following case study presents an insight to this interaction between advice given and its execution on farm over the past 12 months. The goals of survival and minimising losses in the short term have needed to be weighed up against the need to preserve capital and still be a viable and long term producer of milk for consumption by the Australian public.

PROPERTY AND BUSINESS OVERVIEW

"Briar Bank" is a 140ha dairy property with 100 ha of run-off blocks situated on the Shoalhaven River delta at Pyree on the NSW south coast. The region has a unique temperate climate and is capable of growing good pastures in most months of the year. The farm pasture base is diversified and comprises of a mix of kikuyu-rye grass based, perennial rye and some cool season cereal rye pastures in rotation with summer fallow. Summer cropping is tactically employed when conditions allow or if fodder reserves or access is challenged.

Soils are generally fertile and alluvial but shallow due to acid sulphate subsoils and drainage provides some challenges. Rainfall is variable and the region is prone to both dry periods as well as extreme wet weather events.

The herd size varies from 230-270 Holstein cows in milk with development goals to milk 400 plus cows, predominantly off pasture, if market conditions are appropriate. The feeding systems on the farm are simple and comprise of in shed feeding of dairy pellets and hay racks for provision of baled silages and purchased hay. Production per cow is currently at 8230 litres and 553 kgs of milk solids per cow (rolling 305 day production). This is below the historical production levels and potential of the herd. All heifers are kept and reared on farm and are calved at 24-28 months of age. Sexed semen is used in heifers to build numbers, allow culling for milk quality and fertility and, once target herd size is achieved, to provide surplus heifers for sale.

The calving pattern can be broadly described as all year round, however, with previous foreshadowing of higher autumn pricing for milk, and following the drop in tier 2 pricing to approximately 25c in the spring of 2011, the herd had moved to try and calve around 60% of the herd in summer and early autumn.

The business employs 2 full time and 2 casuals (total 18 hours per week) and uses contractors for forage conservation and with major paddock renovation work.

The rapid exit herringbone dairy was built in 2006 to accommodate a 24 aside double up system but was fitted out at the time with 15 units per side. There is an EasyDairy automatic drafting and feeding system in place. The dairy was fully fitted with all 24 units in November 2011. Milking time is now between 75 and 90 minutes plus wash out. Somatic cell count at the time of writing is between 100 and 150 and rarely strays beyond 200. Clinical mastitis cases are very rare and quality bonuses are shared with staff.

The farm has been partially inherited, predominantly purchased and run off areas are currently leased. Key business goals are to expand the business to its potential, to grow income and wealth to be able to reduce debt and to continue to employ and develop high quality staff to allow the owner to spend more time managing and to develop personal interests.

IMPACT OF TIERED MILK

The impact of tiered milk on “Briar Bank” has been similarly devastating to most other dairy businesses. In July the herd had been geared heavily to take advantage of winter incentives and instead received a milk cheque that was $20,000 less than what had been projected. This trend continued until the following November and was exacerbated by engineered reduction in production in response to the tier 2 price at a time of year where milk volumes would normally been at their highest.

A tactical management plan was put in place with the following core principles at its base:

1. Business decisions need to be based on both short and long term factors and need to be objectively, not emotionally assessed, then acted on quickly

2. All cows to be milked were to be fully fed and body condition and production needed to be kept as high as possible

3. The herd to be milked needed to be highly efficient from both perspective of feed conversion efficiency and labour and management

4. Feed costs needed to be reduced but the core focus needed to be margin over feed cost, not costs alone. Diets needed to be tailored to optimise milk quality to maximise milk price. Body condition and reproductive performance needed to be maintained. Pasture performance needed to be optimised to facilitate this

5. Young stock and dry cows are the future of the herd and the driver of wealth creation and future production. The short term market signals needed to be kept in perspective with the bigger picture in mind

6. Staff and service providers needed to be informed and communicated with openly and honestly during this uncertain time and the owner needed to continue to communicate and develop his support network with friends, peers and others in the industry

7. The herd needed to be able to respond to better milk prices quickly when market conditions changed

8. The business needed to maintain itself as an attractive supplier of milk to any milk buyer in the future as this short term crisis could create opportunities

9. The business had to keep these goals in mind with all decision making but maintain an adaptive and flexible response to seasonal and markets conditions.

10. The business will learn what it can from this period and use it to grow a stronger enterprise for the future

Some details of how these principles were executed and some of their outcomes are presented below.

1. Business decisions need to be based on both short and long term factors and need to be objectively, not emotionally assessed, then acted on quickly

With approximately 25% of potential milk production attracting a tier 2 price of less than 15c it was critical to review the effect of this on the financial objectives of the business.

There were long term plans in place to grow the business out to 400 cows producing 3.5 million litres of milk per year but with extremely pessimistic tier 2 price signals, considerable but manageable debt and obligation to both staff and animals under care, short term decisions to reduce costs and streamline the business needed to be made. With the variable cost of the last litre produced, exceeding its value, significant restructuring was required. An extensive culling program was rapidly embarked on and diets and dietary inputs were reviewed closely and modified. The long term need to grow any business and the previous cyclic nature of dairy markets and their opportunities were not ignored with investment in young stock and the productive capacity of the farm and its facilities continued where cash flow allowed.

2. All cows to be milked were to be fully fed and body condition and production needed to be kept as high as possible

Feed is the highest cost for any dairy business. To optimise returns to feeding, feed conversion efficiency needed to be maximised and this is achieved when fresh cows are fully fed balanced rations. When cows are underfed, feed conversion and returns to feeding are reduced and investment in body condition is sacrificed. This flows on to reproduction and cows that are in early lactation will have suppressed lactation peaks. Full feeding of cows has always been a core goal at “Briar Bank”. A decision was made to increase culling and to dry cows off early rather than underfeed the milking herd.

Reduced numbers of milkers allowed a shift towards a higher proportion of pasture in the diet and reduced levels of concentrate in those cows that were retained while still keeping the herd fully fed, even when pasture growth was reduced during the dry spring. When required, concentrate levels were lifted across the herd to keep the cows fed even though the marginal short term milk production benefits were cash-neutral at best. It was important to maintain body condition and keep cows milking well so later lactation production, during what was hoped, and eventually turned out to be, a fully paid period (from December onwards) was not suppressed.

3. The herd to be milked needed to be highly efficient from both perspective of feed conversion efficiency and labour and management

Rather than turning down production across the herd by underfeeding a decision was made to milk a more efficient herd with fewer cows. Any cow in a herd producing tier two milk is potentially “marginal”. Even a cow producing 20 litres of milk at 13c per litre was only generating $2.60 per day of milk income! All cows were individually assessed for current production and productive potential, conformation, fertility and milk quality. Cows with repeated high cell counts reduce milk value. High maintenance and repeat problem cows increase labour and treatment costs.

If a cow was not going to be in the herd in 6 months’ time, there was little point in her being there now. “Marginal” cows could be either dried off early or culled. Their pasture could then be redistributed to the rest of the herd reducing total supplement requirement or moving them closer to a state of full feeding and optimal feed conversion efficiency. In addition there would be significant savings in labour, chemical, power etc. Over 50 cows were identified and removed from the herd.

Most of these were sold early while cull cows prices were still excellent providing a “war-chest” to help cover fertiliser and feeding expenses over the spring. Milking time was cut by 20 minutes and cell counts and mastitis case rates and treatment costs were dramatically reduced.

Pasture was re-allocated to the rest of the herd allowing concentrate levels to be reduced by between 3 and 4kgs/head per day compared to previous late winter and spring periods. Concentrate costs were dropped by approximately $6000-8000 per month. The automatic feed system was adjusted to continue to feed fresh cows to achieve peaks of >35 litres and body condition was maintained across the herd.

4. Feed costs needed to be reduced but the core focus needed to be margin over feed cost, not costs alone. Diets needed to be tailored to optimise milk quality to maximise milk price. Body condition and reproductive performance needed to be maintained. Pasture performance needed to be optimised to facilitate this.

The concentrate formulation was closely assessed. The whole pellet contained numerous additives, all with strong evidence base for their marginal gain in both milk production and animal health. These included monensin, virginiamycin, biotin, organic zinc and bypass fats. Each was assessed on its individual short term and long term merits with a decision made only to remove the bypass fats during the period. Tier 1 pricing would be optimised by maximising milk component percent as opposed to maximising total yield. The pellet formulation was modified at some additional cost from base formulation to increase the proportion of slow fermenting starch sources using maize and reducing the proportion of rapidly fermenting wheat.

Pasture inputs were also closely assessed during the period. Long season Italian ryegrass cultivars had already been selected to maximise potential for late season pasture driven production and silage quality. A pre-committed late planting of perennial ryegrass was carefully established during the early winter with a view to its value in the following autumn and winter.

Nitrogen inputs were kept high as additional dry matter from nitrogen was likely to cost only between 5 and 10c/kg of dry matter, significantly cheaper than any other purchased feed input and the goal of full feeding from pasture needed to be maintained. Capital inputs of spring potassium were reduced but some still went it as part of a NKS blend. A significant nitrogen inventory was retained on farm allowing the business to take advantage of short lasting frontal rain events if they occurred.

The significant one off rain event in October was met with 20 tonnes of urea during what was an extremely dry spring and early summer period. Rotation lengths on pastures were also modified and extended compared to previous years. Optimal pasture yield and nitrogen use efficiency was most likely if rotations were extended to allow ryegrass to achieve 2.5-3 leaf stage in winter and early spring and 2-2.5 leaf stage in later spring. To minimise requirements for supplementary forage to support rumen function, there was a need to source effective fibre from the paddock.

The longer rotations, combined with the changes in concentrate formulation allowed the herd to maintain butter fat levels between 3.5 and 3.8% at a time of year where much of the district was dropping below 3%.

With each 0.1% of butterfat worth approximately 0.4c/litre in tier 1, the combination of reduced concentrate costs (due mostly to lower feeding levels to less cows) and improved milk price for tier 1 more than offset the reduction of tier 2 litre valued at 13c at that time.

Cows were not significantly turned down and were able to rapidly respond to improved milk prices in December. Continued investment in pastures and focus on pasture management allowed the business to make the most out of a very poor spring.

5. Young stock and dry cows are the future of the herd and the driver of wealth creation and future production. Animal health cannot be compromised. The short term market signals needed to be kept in perspective with the bigger picture in mind.

With early dry offs, dry cows numbers were increased. Nitrogen was still applied to run off blocks during spring to feed dry cows and older heifers. A possible silage cut was foregone to keep non milking stock well fed. Younger calves were kept on milk longer as 13c milk was an effective way to keep them growing well for longer, reducing need for high level supplement feeding during the dry spring. The sexed semen program in the heifers continued as the long term plan was to grow the herd when market conditions improved and the calving benefits of heifer calves from heifers had been well established.

Lead feeding continued although a change to a “middle-shelf” lead feed that still effectively prevented milk fever while not achieving optimal milk production was opted for. As such calving problems and calving related disease was minimised with obvious flow on effects for cow health, reproduction and labour. No changes were made to dry off protocols with dry cow antibiotic and Teat Seal still used in all cows.

6. Staff and service providers needed to be informed and communicated with openly and honestly during this uncertain time and the owner needed to continue to communicate and develop his support network with friends, peers and others in the industry.

As soon as the changes in pricing were announced a meeting was held with all staff informing them of the situation and its implications on the farm business. All staff were retained and their job security reaffirmed, but the importance of their rolls and job performance were re-iterated.

Continued communication with other farmers, friends and service providers was critical and a strong peer support network was further developed and maintained.

7. The herd needed to be able to respond to better milk prices quickly when market conditions changed

The manager and advisor had both agreed that the likely outcome of both the pricing policy and its suppressive effect on the states milk production combined with challenging seasonal conditions would be likely to bring forward a highly predictable shortage of milk. As such the herd needed to be kept in a state where it could produce close to its potential when full pricing was restored to all milk. This occurred in December, 2 months earlier than anticipated by the processors. Heifers had already been programmed to calve in November and December to take advantage of this probability.

The variable feed system in the dairy had been used to shift concentrate from late lactation cows that would be less likely to milk through into the high paid period across to the fresher cows to help build milk production in later lactation. While break-even at best in the short term, this shift in feeding in the fresher cows helped maintain body condition, assisted with reproductive performance and had carry over effects into later lactation. As a result, the herd was able to produce at between 25-28 litres per cows across the summer period capitalising on the removal of the tier two price from the beginning of December. It also meant that the returns to feeding near fully purchased ration across the extremely dry summer were also optimised as a higher proportion of purchased feed was able to be channelled into production rather than maintenance and rebuilding body condition.

8. The business needed to maintain itself as an attractive supplier of milk to any milk buyer in the future as this short term crisis could create opportunities

While proximity to Sydney had always been an advantage, the deterioration in traditional relationships between the supermarkets, processors and farmers combined with broad based discussion of further industry and logistic driven processor rationalisation had reinforced the need to continue to be focussed on markets with business planning at “Briar Bank”.

This, coupled with examples of more direct relationships between farmers and retailers in the UK and strong industry rumbles of similar things occurring here, sent signals that dairy businesses that were going to survive needed to be more responsive to end user requirements. High standards of milk quality with respect to both somatic cell count and components, and adequate volumes of milk to justify pickup from any potential future processor would be essential. It was also critical that the previous high standards of animal well-being and commitment to staff were maintained in a milk market environment demanding ever increasing levels of public accountability. The continued review of herd structure and modification of rations addressed many of the milk quality issues during the period. The capacity of the business to rapidly grow if need be was addressed by continued commitment to the heifer development program with culling and stock sales occurring at the mature end of the herd rather than taking some of the opportunities that had been available in the export heifer market.

9. The business had to keep these goals in mind with all decision making but maintain an adaptive and flexible response to seasonal and markets conditions.

Despite having the previous mentioned goals and objectives at its core, the extremely dry season of spring and summer 2012, brought with it many additional challenges. To be able to maintain production, a flexible approach to management decision making was required. Despite best intentions and aggressive use of fertiliser during scarce rainfall events, pasture growth and conserved forage objectives were not met. The combined run-off blocks and dairy platform had previously been able to generate sufficient pasture surplus to provide the majority of silage and hay for both summer and winter feeding. A combination of drought and increased pasture allocation for both dry stock and milkers had removed capacity to generate spring surplus.

Plans were made to proceed with 20 hectares of summer cropping, however with continued dry weather and heat, the risks and costs of this were considered too high and cropping plans were abandoned. Instead, 200 tonnes of cereal hay from the Riverina was secured, which at the time was well priced (similar costs to growing maize silage) and of good quality.

This lower risk option was also more suitable to the feeding and feed storage systems at "Briar Bank". The areas that would have gone to summer crop were able to produce a small late hay cut and were then placed in summer fallow. This area subsequently formed part of an early planting of rye and cereals allowing three grazings to occur before June 2013 on the home block and a cut of silage in early May on the run-off block.

10. The business will learn what it can from this period and use it to grow a stronger enterprise for the future

This statement very much speaks for itself. Previous droughts, challenges with deregulation, shifting input prices and milk price variation have all provided valuable lessons for those that choose to learn. The current period of turmoil has re-enforced the value of acting objectively and decisively and paying close attention to both market and seasonal signals with farm management decisions.

The value of milking a low maintenance, labour and feed conversion efficient herd at any time cannot be over-emphasised as well as maintaining core principles of full feeding of cattle and making the most out of the pasture base where possible. The benefits of communication and peer support arising from relationships with other farmers and service-providers should not be underestimated. Short term challenges often require difficult and decisive action, however, this needs to be kept in perspective with the bigger picture and future in mind.

We are still here and are excited by the future!

Building a Business Brain

G. Mills

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- A simple understanding of how our brain works can have significant impacts on our success in business and in life. Actively choosing how we set our frame of reference to be more positive and possibility driven is a fundamental key to this process.

- Setting our brain up to find the key bits of information we need and then making the time to focus on these will weigh the odds in favour of business and personal success

- The three major influences on this are: ***who you associate with, what you read and what you listen to***.

When we think about the evolution of the human brain over thousands of years, one question to ask is if its design is compatible with multitasking in the modern business world. Technologies such as the iPhone®, that was only introduced to the world six years ago, have changed how we run our business on a daily basis. Yet the software we use to control our brains may not be so modern, and the user manual may be sitting on the shelf gathering dust.

The architecture of the human brain has evolved to help us survive in an environment completely foreign to the modern business world. A brain designed to focus on one issue at a time, such as the animal you are hunting for dinner, may not be best suited to dealing with the complex issues involved in modern business. When you are hunting dinner you want your brain focused on the job at hand and not being distracted by unimportant things that are going on around you. While in the modern business there are many things happening at once that may need your attention.

At any one time your brain may need to deal with more than two million pieces of information being sent to it from your various senses. As the conscious part of the brain cannot deal with such a volume of information, the brain specialises in deleting the bits of information that are not important. The big question is: what is not important. Different people will have different criteria on what 'is' and 'is not' important to them, and this changes with time. Sections of the brain reduce these two million bits of information to a little over a hundred that it can deal with. This results in a range of permutations of what information different people will draw from the world around them.

Depending on your frame of reference as to what is important, the brain will pay attention to those bits of information which meet your criteria of relevance, and delete the remaining information bits without processing them. So if you think the world is full of opportunity, or you think it is a terrible place and we all will be ruined, there will be something in the two million bits of information that will fit either frame of reference. If you think that a problem is solvable the brain may not delete the bit of information that may lead you to a solution. If you believe there is not a solution to the problem these bits of information are seen as irrelevant to your frame of reference and may be subsequently ignored.

Peoples' success is often attributed to 'luck', 'being in the right place at the right time', 'marrying well' or 'getting more rain'. While not the magical answer, knowing how the brain works can weigh the odds a bit more in our favour. Reprogramming the brain to look for the opportunities and solutions to problems can help our business move forward. Knowing how the brain works and using this to our advantage can improve the odds of business and personal success.

A key to success is telling the brain what is important so that key bits of information are not inadvertently deleted. The three major influences on this are: ***who you associate with, what you read and what you listen to***. If you associate with people who are looking for solutions and solving problems, your change in belief will encourage your brain to look for new opportunities in the world around you. Whereas if you associate with people who are negative about life and business, you can be programing you brain to stop looking for new opportunities.

Submersing yourself in negative environments will encourage your brain to find those things around you that support this negative view, rather than finding those that are positive and contribute to solutions. How our brain functions makes actively seeking out and associating with successful and positive people a major key to business and personal success. Likewise, feeding the brain with positive and enlightening reading and audio material will also program the brain to the positive possibilities that exist in the world. This will assist the brain in recognising the bits of information which are important and not delete them before the brain can consciously process them.

Positive thinking alone will not solve the problems of the world, thinking without action is little more daydreaming. Thinking that the garden has no weeds will not remove the weeds from the garden. But the physiology of our brains means that opening our minds to positive possibilities will allow us to find those bits of information around us that will contribute to our business success. This will not happen by accident and we must actively adjust our belief systems so that our brain knows what is important and which bits of our world it should ignore and which bits it should give special attention.

While many people think that they are good at multitasking the reality is that as little as 2% of the population can multitask successfully. In evolutionary terms focusing on a single task was more important to survival than multitasking. Hence our brain is not wired to deal successfully with many issues at the one time. This is critical to know in improving business success. We must take time to allow our brain to focus on key issues in our business away from the day-to-day distractions.

While involved in the daily tactical task of running a business it is often not possible to give the necessary attention to the strategic decisions that will ultimately determine the business success. In practical terms this means scheduling time to think and gather information. While no one likes meetings or extra time in the office, this can often be a key to success if used to focus on what is important in the business.

This means no phones, no interruptions and scheduling the meeting at a time of day when you are fresh and alert. Meetings should be scheduled in advance as this will trigger the brain to start thinking about the key issues and start the process of finding solutions. When you take this time out of the daily tasks of your business, it is important to focus on the more strategic decisions that will impact on your long term business success. Taking time out from daily tasks to talk and think about those daily tasks is of minimal benefit and is often why people do not like meetings.

A simple understanding of how our brain works can have significant impacts on our success in business and in life. Actively choosing how we set our frame of reference to be more positive and possibility driven is a fundamental key to this process. Setting our brain up to find the key bits of information we need and then making the time to focus on these will weigh the odds in favour of business and personal success.

The Social Science of Taking Control

Putting it to the test

G. Mills

Farmer Profile
Graham Finlayson
'Bokhara Plains', Brewarrina NSW

Graham Finlayson is from Brewarrina, a small town almost 900km northwest of Sydney. He owns and manages, along with his wife Cathy and daughter Harriet, the 18,000 acre cattle trading and breeding enterprise "Bokhara Plains" in an intensive planned grazing system.

Graham graduated from Longreach Pastoral College in Queensland, and then worked in a family farm partnership till purchasing "Bokhara Plains" with his wife in 1999. He has since ridden a steep learning curve in his desire to greatly enhance the ecological and productive capacity of landscapes, people and communities throughout the rangelands.

Studying in detail the principles of Allan Savory's Holistic Management, and also learning under Terry McCosker with his 'Grazing for Profit' and Executive Link programs, has seen a vast improvement in the capacity of their land. Graham was the recipient of the NSW Farmers 'Young Farmer of the Year' award in 2006 for regenerative farming and diversification into tourism; a Regional Primary Production award in 2007; and a prestigious Nuffield Farming Scholarship in 2008. The Scholarship was to study regenerative land management on the rangelands of other countries using well managed livestock.

For the last twelve months Graham has also been employed in a consultancy capacity as a 'mentor' by the Western Catchment Management Authority for landholders involved in their new Innovators program. Recently the business and farm has also been included as one of only 19 Australian farms documented as a case study in Outcomes Australia's 'Soils for Life' project for regenerative agriculture.

Graham believes livestock have been unfairly vilified in environmental and greenhouse gas debates. He says livestock have the potential to be one of the most ecologically and economically effective tools available in repairing degraded rangelands and restoring the world's carbon balance. Holistic management is the key to regenerate grasslands, using intensive planned grazing for short periods of time, followed by long rest periods.

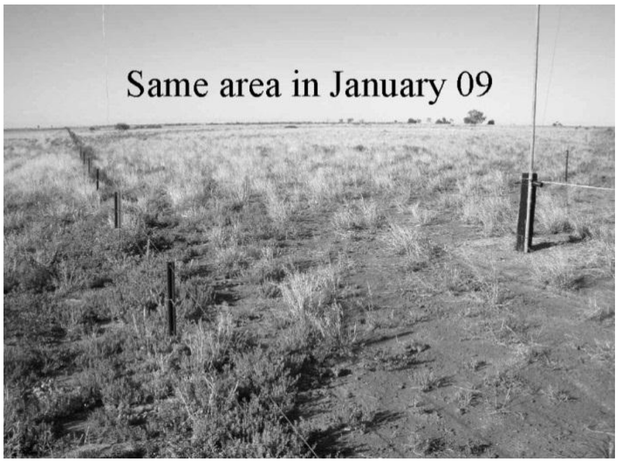
Graham uses the cattle's hooves cut up the soil surface, making it easier for seeds and nutrients in their manure, as well as subsequent rain, to enter the soil. The plant matter they don't consume is also broken down, adding more organic material and nutrients to the soil and, importantly, building soil carbon. The rest period gives seeds the opportunity to germinate and establish strong root systems, further sequestering carbon below ground.

Graham has already seen positive results from the process on his property, particularly on some of the light 'scalded' soils. Soil fertility has improved, grasses have established more effectively and have also become more resilient after grazing, he says. The holistic management approach has dramatically changed his thinking over the past few years, encouraging him to focus on the cause of problems, rather than fighting the symptoms, such as weeds, and on drought proofing his business, rather than his property.

Farmers that Graham visited overseas had been using holistic management for more than 30 years, and the differences in the health and productivity of these properties, compared with those under conventional management, was inspiring.

Graham believes that problems like weeds are often nature's way of trying to heal a problem, to restore water and nutrient cycles that we have broken down with European-style farming practices. He is restoring the balance with management styles that better mimic natural processes – like the migration of herds across rangelands, where large numbers of animals are making a big impact for a short time.

Graham has developed a much greater appreciation of the diversity of views and flexibility of agricultural systems around the world following his Nuffield Scholarship. The program gave a rounded view of agriculture globally, as well as the chance to pursue individual research interests.



An example of the changes achieved on Bokhara Plains from 2004 to 2009.

Putting it to the test

G. Mills

Farmer Profile
Mike Jeffrey
‘Kempsey, NSW

Mike Jeffrey left school and came home to the family farm 1984 before starting work off farm with NORCO herd improvement.

Thus began a long career in the AI industry which included travel to the USA and Canada. In 1994 Mike joined World Wide Sires breeding company managing their NSW and QLD territories. After working in Italy, USA, Canada and Germany he bought into the WWS business with two partners in 1996.

In 1999 Mike ran a project developing dairies and exporting heifers into Indonesia. In 2001 he was involved in setting up several large dairy farms, training and consulting programs in Vietnam whilst also undertaking a number of project management and consulting projects in China, with a company he and two partners set up called International Agricultural Exports, before coming back to run his farm in 2008.

He stepped away from the AI and Export industries to spend less time travelling and more with the family. In 2010 Mike and his partners sold WWS to Genetics Australia.

Seeking another challenge, Mike joined the board of NORCO in 2012. Mike has used off-farm work and investments to buy more land and build up the existing herd size.

Mike has been able to grow from 50 ha and 100 cows in 2000 to 165 ha today milking 300 cows.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Robotic Dairy Operation

J. and A. Henry

Dairy Farmers, Pyree, NSW

- Robotics created opportunity for John and Andrea to re-enter the dairy industry whilst keeping their contracting business operational
- Contracting business influenced design of system type for the AMS dairy
- Cows are housed in a barn with composted bedding and completely ‘free-cow traffic’
- Monitoring data allows for early detection of illness and oestrus.
- System flexibility and its impact on labour/lifestyle is a key benefit for us.

OUR OPERATION

Before 2009 our core focus was our agri-business contracting. 240 ha was used to contract grow conserved forages and run beef cattle. We were both from dairying backgrounds and were keen to get back into dairying but our options were relatively limited if we were to keep the contracting business operational. Robotic milking provided an opportunity for us to re-enter the industry with the confidence that Andrea, and a part-time staff member, could manage the dairy aspect of the business even during the most chaotic contracting periods.

The fact that we have so much machinery was a strong influence in the design of our AMS farm/facility. It made sense to us to bring the feed to the cows because we had sufficient equipment to do that and it was a system that we believed was less challenging because of all of the knowledge and experience from overseas indoor AMS farm installations. John had visited 6 commercial farms in Holland 12 years before making the decision to invest in AMS and Andrea had also visited the FutureDairy research farm with groups of TAFE students. So the concept was derived to operate a “free cow traffic” AMS with cows fed a mixed ration and “cut and carry” fine green chop forage. Ours is the only AMS farm in Australia that has free cow traffic – this means that we don’t have any drafting gates to direct where cows can go and when. Our cows are free to traffic in any path between milking, feeding and loafing without being exposed to any level of restricted access to any of those three areas. The only incentive we have in place for cows to be milked is the provision of their allocation of concentrate in the robots. We believe this is a very cow friendly design that gives cows full flexibility to choose their activities and routines.

Another unique aspect of our design is the composted bedding that we have in the loafing area. To the best of our knowledge, no-one in Australia is operating any kind of cow barn with composted bedding. This has been a steep learning curve for us and has truly been a matter of trial and error. We have struggled to get any advice in this area due to the lack of existing knowledge but over time we have come up with a system that works extremely well for us. We clean out the barn completely when necessary and apply the composted bedding to our paddocks. We use straw and sawdust for the bedding material and apply lime strategically. For us, the composted bedding has proved to be successful with no real animal health issues and both the capital and ongoing operational costs are very low. The only real challenge that we have is the lack of natural wear on hooves which means that to the hooves of our cows require regular trimming.

COMMISSIONING

We commissioned our dairy in October 2009 with 40 cows and 2 x Lely A3 Next. Within 2 months we had grown the herd to 100 head and since then we have grown the herd to 130 cows by keeping all replacement heifers. We had originally planned to grow the herd to around 140 cows but we reassessed that and were comfortable with 130 cows for our operation and targets.

We commissioned with cows at all stages of lactation – this is what we were able to source with regard to purchased cows but it also suited our intention to milk with year-round calving. We managed to purchase Holsteins, Brown Swiss and Illawarra's initially (original 40 head). An additional 60 cows were introduced to the system over a 2 month period. We now milk 130 cows and have found that only 2 cows were culled for undesirable udder conformation during the scaling up. The remainder of the cows adapted to the system extremely well. Our current herd is comprised of Holsteins, Jerseys, Jersey crossbreds, Brown Swiss, Illawarra, Aussie Red, Guernsey and Ayrshire. We have targeted the mixed breeds for educational and demonstration purposes with our dairy tours.

For us it was extremely pleasing to see BMSCC drop continuously throughout the first few months and for the production level of the cows to increase as time progressed.

FARM MANAGEMENT SYSTEM

We have a strong focus on maintaining a simple operation which has a reasonably high level of flexibility. Whilst concentrate is offered to individuals in the robotic milking units, generally John or one of our contracting business staff members brings feed to the cows during the early morning before heading off to conduct the days contracting. This feed is typically a mixed ration comprising of maize silage, hay and minerals. Late in the day an allocation of fine, green chop forage is bought to the barn. On occasions the green chop is replaced with another allocation of mixed ration (dependent on seasonal conditions). All feed is placed on the concrete feedpad and cows access this through feeding rails.

Throughout the day we use a tractor operated mechanical feed pusher to keep feed within reach of the cows and we find that feed wastage is minimal. Any feed that is scraped from the feedpad is offered to replacement heifers. We make use of the individual cow feeding capability of the AMS through implementation of a production based feed allocation for our grain based concentrate.

We fetch cows that haven't volunteered for milking 2 times each day (morning and afternoon). These are typically stale cows, cows on heat or inexperienced heifers that have only recently calved into the system. This task usually takes about 30 minutes each time. We have one AMS that has a waiting yard available to it. We encourage fetched cows into this yard and program the gates so that the yard reopens after the set number of cows has passed through that robot. This automatic gate then ensures that the robot becomes freely available to the remainder of the herd again without relying on us reopening that yard.

SYSTEM PERFORMANCE

We measure our system performance slightly differently to most conventional dairy farms. For us production per cow is important but we also pay particular attention to the production efficiency of individual cows (impacted predominantly by milking frequency, milk harvested per day and milking speed). We closely monitor any cows that have an incomplete or failed milking as it can be an early indicator that assistance or intervention is required. Other data that we pay attention to on a daily basis is the indicators of udder health and oestrus/heat probability.

Table 1: Farm system performance

	Commonly achieved average ranges throughout the year
Production per cow	25-30 litres/c/day
Milking frequency	2.4-2.8 milkings/c/day
Milking speed	6-9 minutes/c/milking

KEY SYSTEM BENEFITS

For us milking cows conventionally was not really an option because we didn't particularly want to employ a full-time labour unit which would have been necessary for us to manage a dairy operation whilst continuing our contracting business. Our investment in AMS has allowed us to get back into the dairy industry without compromising our wider business. Some aspects of our operation have involved a relatively prolonged learning curve (predominantly the composted bedding) but the cows (and us) settled into the system remarkably quickly. Within about 6-8 weeks of commissioning we were getting reliably good voluntary cow traffic and milkings. The flexibility of the system operation suits us very well and the working days are very amenable for both us and our employed staff.

We do employ part-time staff to ensure that we always have someone trained to operate the system if we are absent but the hours of operation mean that the role is attractive and we don't have any issues with attracting or retaining staff. We find that the system is operator friendly and we use the SCC data and conductivity to detect mastitis easily which allows us to maintain a BMSCC around 150,000 cells/ml. We also use deviations from normal cow behaviour and cow traffic to provide us with an early warning of illness and oestrus and therefore we can react and respond to these indicators in a timely manner.

Breeding cows suited to Automated Milking Systems - AMS

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- Specific breeding objectives for AMS are generally common to CMS but might have a higher level of emphasis when milking occurs without human intervention
- Central teat placement, moderate length teats and a level floored udder (untilted) are ideal for AMS
- Locomotion and mobility are important and cows bred for sound legs and feet may be better positioned to perform at higher levels in the AMS by having a significant increase in traffic, milking frequency and resultant production
- Opportunities exist for AMS farms to contribute significantly to National pedigree and production reporting systems

BACKGROUND

Traditional breeding programs across the world have focussed on a highly productive dairy cow that can produce top quality milk across multiple lactations. The absolute targets are somewhat dependent on country. Some countries favour volume where milk is largely consumed as a liquid, where-as countries like Australia and New Zealand favour the components of milk in protein and fat yield as a large proportion of their milk is dehydrated for export.

The conformation of the Dairy cow has been the focus of improvement globally, with individual cow classification providing a very useful data source for not only International bull proofs, but also for artificial insemination breeding decisions based on certain traits for particular breeding objective(s).

The introduction of robotic or automatic milking systems (AMS) across the world has created a new focus that is specific to the aims associated with milking cows without human intervention and the associated system.

BREEDING AIMS – AMS

The breeding aims for AMS should be focussed on ensuring that AMS dairy cows can handle the challenges of robotic milking under Australia's grazing conditions. Cows of medium size with excellent mobility and locomotion together with udders suited to AMS under which they will be milked are desirable.

1. **Medium sized cows**

Medium sized cows are favoured to handle walking increased distances and are considered to be more efficient in an AMS grazing system as distinct to larger sized cows in an AMS feedlot where walking distances and grazing are not part of the system.

2. **Udder focus for AMS**

Requires cows to have front and rear teats which are not positioned too wide or angled nor indeed too close or crossed in (readers are referred to the reference Tech Note 14: Rear Teat Placement ABV, ADHIS). Ideally the rear teats should be positioned in the centre of the rear quarters rather than towards the outside or inside of the lobes. With an increased emphasis over many years of bringing teats closer together, many herds are trending toward close rear teat placement resulting in an increased incidence of the rear teats crossing-over making teat attachment by robot difficult.

Crossed or angled rear teats that are too close can be a problem for a robotic system (tending towards a score 9, see figure 1 in attached Tech Note). The ideal teat position for an AMS suited cow is described as a 5 or centrally placed on the udder quarter. Cows with front or rear teats positioned too wide (linear score 1) or too close (linear score 9) present teats that are angled and more likely to be challenging for robotic systems. The easier the robot can attach the cups, the greater the potential milk harvesting ability of each robot – improving the efficiency of operation allowing the robot to conduct more milkings per cow or to milk more cows in total.

The ideal udder for an AMS cow is not only focused on teat placement but takes into consideration the desire to breed level floored udders rather than tilted udders. Teat length has also been identified a criteria for breeding selection as too short (linear score 1) or too long (linear score 9) is not desired.

3. **Locomotion**

The walking distance involved in any pasture-based grazing system demands that cows can walk freely and without lameness and that they are willingly to do so. Lame cows will not travel the distances required to function under an extensive grazing system. In this regard, pasture-based cows should be selected for sound feet and legs with:

- Intermediate set or curve to rear leg as observed from the side view

- Good positive rear heel depth (not too shallow)

- Positive locomotion - rear legs from a rear view

Cows in pasture-based AMS will be required to walk freely between the paddocks (via the AMS milking system). Cows that have good mobility and locomotion may be more inclined to traffic around the farm system more frequently allowing additional benefits of the AMS to be harnessed through increased production.

4. Rumps

Should be sloped to encourage correct reproductive tract drainage. This also encourages good thurl position and rear leg alignment.

BREEDING SUGGESTIONS

An AMS herd would be best suited by a breeding program that was inclusive of the important traits listed above where the optimum linear score is tending to the middle of the trait range rather than the extremes of the trait range.

A potential "threat" to robotic milking would be the trend to select bulls that breed daughters with:-

a) Very wide or very close rear teat placement - linear score 5 is optimum

b) Very weak or very strong udder ligaments this also influences teat position

Breeding generation over generation of "strong" udders can actually over-correct the two traits outlined above and cause future issues for an AMS system.

AMS AND HERD TESTING TO THE FUTURE

The development of AMS has resulted in AMS famers having access to individual cow milk yield and milk quality data on a daily basis. The collection of this data along with accurate cow identification will provide an opportunity for State and National Herd Improvement bodies to engage with these AMS systems and harness their data to explore means by which yield and milk quality (e.g. % Protein, % Fat, Mastitis indicators) can be used for National Genetic reporting and the incorporation into Breeding Values.

The movement of AMS generated herd data from individual AMS farms to a National body or database will ensure that these herds remain engaged and avail themselves to the National pedigree and production reporting systems that are offered through traditional means. It is important that all efforts are made to develop data transfer systems that allow important animal pedigree, production and health data to move in and out of AMS farms. To isolate these AMS herds and not encourage data transfer would be to the detriment of both the AMS herd along with the State and National Herd Improvement bodies.

Appendix 1: Rear Teat Placement ABV

Technote No. 14

Rear Teat Placement ABV

Australian Dairy Herd Improvement Scheme

Key Messages

- Farmers wanting to improve Rear Teat Placement can now include this trait in their breeding objective to:
  - narrow the distance between rear teats, select for bulls from *The Good Bulls Guide* with a Rear Teat Placement ABV more than 100; or
  - widen the distance between rear teats, select for bulls from *The Good Bulls Guide* with a Rear Teat Placement ABV less than 100.
- You can find ABVs for all traits, including Rear Teat Placement, at www.adhis.com.au.

Introducing Rear Teat Placement

In some cows, applying a cluster during milking is difficult because of close or crossed rear teats. In recent years, breed societies have scored the rear teat placement of heifers during classification. This data has been used to develop an Australian Breeding Value (ABV) for Rear Teat Placement that will allow farmers to breed for this trait from April 2011.

Data for Rear Teat Placement is collected through the linear type evaluations of first lactation females. On a scale of 1-9, breed society classifiers assess and record the position of the rear teats in relation to the centre of the quarter as illustrated in Figure 1.

An analysis of 7,060 Holstein and 1,657 Jersey cows scored in 2010/11 found a phenotypic mean score is 7.1 in Holstein and 6.5 in Jersey, indicating that both breeds tend to be closer to the crossing end of the scale.

How is it expressed?

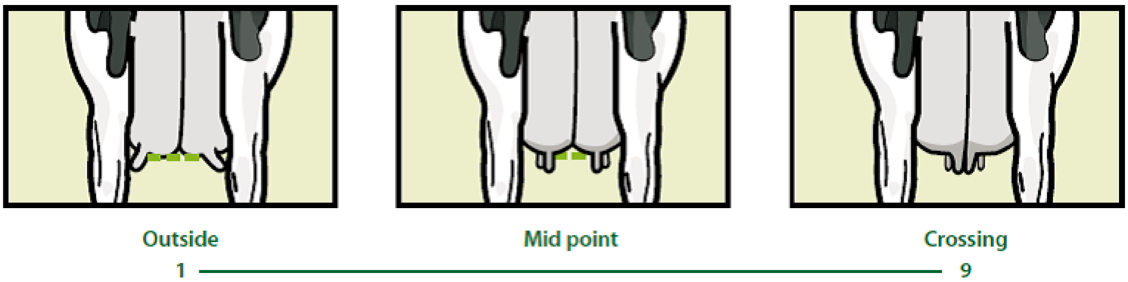
Using the data collected about a bull's daughters, information from the bull's pedigree and genotype, ADHIS calculates and reports the ABV.

Rear Teat Placement ABV is expressed as a percentage more or less than the average of 100. Average represents the modern dairy cow. Each year, ADHIS updates the average (base) to ensure it reflects the current milking population. This is set at 100 for non-production traits, such as Rear Teat Placement.

Rear Teat Placement is an example of a trait where neither extreme is desirable. Therefore, the direction of expression can be tricky. The Rear Teat Placement ABV is expressed:

1. In the same direction in which the linear trait is measured (higher is closer).
2. In the same direction as Front Teat Placement (more than 100 is closer).
3. In the same direction as many foreign countries currently express the same trait (more than 100 is closer).

Figure 1: Classification of the position of the rear teats in relation to the centre of the quarter.



How can I use it in my breeding program?

There is a range in Rear Teat Placement, as demonstrated in Table 1, meaning farmers will be able to select for closer or wider rear teats.

- To narrow the distance between rear teats, select bulls from *The Good Bulls Guide* with an ABV more than 100.
- To widen the distance between rear teats select bulls from *The Good Bulls Guide* with an ABV less than 100.

Table 1: Ranges and Means for Rear Teat Placement ABV (August 2010).

	Holstein	Jersey
Number of bulls	82 736	4228
Stand Dev.	8.68	5.54
Mean	98.05	97.93
Minimum	52	76
Maximum	132	117

Heritability is an estimate of the level of genetic control for a trait. As such, genetic gain is more rapid in high heritability traits compared to low heritability traits. The heritability of Rear Teat Placement is 0.25, meaning that it is moderately heritable and the pace at which changes can be made is similar to traits such as fore and rear udder attachments.

In dairy cattle breeding, most traits have a relationship with each other. For example, there is a positive relationship between protein kilograms and milk litres. More milk generally means more protein. These relationships are known as correlations and are reported in a range between -1 to +1. In the case of rear teat placement, the genetic correlation between rear teat placement and front teat placement is strongly positive at 0.71. This means that as you breed for closer front teats there is a strong tendency to have closer rear teats, but this is not always the case, as such the Rear Teat Placement ABV will provide direct information to farmers about this trait. Correlations between rear teat placement and other udder traits are shown in Table 2.

Table 2: Genetic correlations between rear teat placement and other udder traits.

	Genetic correlation	Description of the relationship
Front Teat Placement	0.71	Strongly positive
Centre Ligament	0.81	Strongly positive
Mammary System	0.61	Strongly positive
Udder Depth	0.07	Very little relationship

You can find ABVs for all traits, including Rear Teat Placement at www.adhis.com.au.

The introduction of Rear Teat Placement is another example of the continuous improvement ADHIS undertakes to provide opportunities for farmers to benefit from genetics.

For more information, contact ADHIS.

ADHIS is an Australian Dairyfarmers Ltd (ADF) initiative that is backed by dairy farmers through their Dairy Service Levy and government funds.

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The Clover Hill Dairies Story

L. Strong

www.cloverhilldairies.com.au

'A shared vision is a critical component of a successful partnership. Vision is what guides where a business is going and how it will get there; it is the plan and the path for the future. A shared vision allows partners to reconcile their goals and their methods for achieving those goals. Without a shared vision partners usually find themselves pulling in different directions'.

THIS IS OUR STORY.....

Like many family business the Clover Hill Dairies team of Michael, Lynne and Nicholas have a different vision for the business. What we do have in common is the mission to "be" the image we want our customers to see. Our customers want to purchase from farmers who practice the things they value – whether it be animal welfare or environmental protection. They want food produced in a way that is consistent with their own personal values and our aim has been to develop a highly efficient dairy system on a small acreage that meets or exceeds those consumer expectations. We know that building trust with consumers will be what sets apart the successful primary producers of the future.

We have worked on all fronts to minimise Clover Hill's environmental footprint. Effluent recycling systems ensure waste is turned into grass, and not allowed to fill waterways. Laneways and off-stream system of troughs maintain a separation between the natural environment and the farming environment. Pastures and fertiliser are carefully matched, to ensure minimal leaching of nutrient in Jamberoo's high-rainfall environment. High production per cow and hectare allows us to focus on minimising emission intensity.

We take every importunity to communicate the story that intensified farming and the environment can happily co-exist. Through extensive engagement with Landcare and programs like the Art4agriculture initiative, a regular stream of visitors passes through the dairy, taking away an impression of farming as consumers would like it to be: productive, environmentally sustainable and picturesque.

THE MILK BUSINESS

Clover Hill Dairies is a 7th generation family-operated business located at Jamberoo on the NSW South Coast.

Our milk business has grown rapidly over the last 14 years reaching a peak of 6.2 million litres per year from 500 cows milked 3 times daily on two farms with an effective milking area of just 110 ha .

Whilst the two farms are located within two kilometres the topography is very different.

The home farm Clover Hill (Farm 1) is situated on the northeast face of Saddleback Mountain at Jamberoo NSW. Located at the headwater of three major tributaries of the Minnamurra River, a sensitive wetland and mangrove environment, Clover Hill is 100 ha in total, of which only 50ha is farmed. The remaining 50ha contains large areas of important high conservation value remnant rainforest and is fenced off to prevent stock access.

Clover Hill is unique; not only is it located in very steep rainforest country; it is also part of a dairy-centric rural residential subdivision of blocks ranging from 0.4ha to 40ha. The farm and the 12 rural residential landholders have formed an incorporated landcare group to work together to protect and enhance the unique community environment of farming land, rainforest and waterways and ensure the dairy farm is a long term thriving commercial enterprise.

Our commitment to stewardship starts from the ground up. We focus on maintaining good soil fertility and structure and grass cover with pastures based on kikuyu and Italian ryegrasses. This has helped avoid the problems of erosion, soil loss and pugging associated with other high-intensity farms.

At Clover Hill we milk the fresh herd (up to 150 days in milk) three times daily.

Lemon Grove Research Farm PL (Farm 2) was established in 2008 to diversify our enterprise. It is 60ha of alluvial river flats at the head of the sensitive Minnamurra River flood plain. The farm is leased and we milk the 150 days in milk plus cows 3 times daily here and also undertake agronomic and pharmaceutical milk trials.

This farm also has a high urban interface being located adjacent to the Jamberoo Township and receives 33% less rainfall than Clover Hill.

Productivity KPI's:

- 2.5 x industry average cows grazed per hectare
- 6 x industry average litres of milk produced per hectare
- 12 x industry average water use efficiency per hectare

- One of Australia's most water efficient milk production systems producing 42 x the industry average of litres of milk per megalitre of water used

- Milking 3 x daily reduces greenhouse gas emissions by up to 30% per litre of milk produced

RESEARCH AND INNOVATION

Partner Lynne Strong is one of 32 Climate Champions across Australia who are advancing climate change knowledge to inspire other farmers to adapt and use resources wisely, reduce pollution and mitigate the impact on their business of climate change legislation. The Climate Champions are also engaging with scientists and extension specialists to ensure climate change research is appropriately conducted and then delivered to farmers in a language they can understand and results they can use.

Recognising farmers learn from other farmers and are motivated by seeing the science work in their own backyards they are actively engaging with government to ensure funding for on farm extension is seen as high priority.

From a grass roots perspective Lynne is critically aware of the need for research to deliver a good return on investment in the shortest turnaround time

For the Clover Hill Dairies team we are excited by research that could:

- Make our and the staff's work/life easier

- Make our product more valuable to sell or provide additional income

- Reduce our costs and our risk profile and improve our business efficiency

- Improve amenity and make our farm asset more valuable

- Improve the welfare and productivity of our livestock

- Reduce threats to our business from red and green tape

- Make us feel better about improving broader scale environmental outcomes

- Be affordable and implementable given the realities of our business cash flow

Lynne is a champion of targeted research and was excited by the research opportunities leasing Lemon Grove could potentially provide

Participants at the 2013 Dairy Research Foundation Symposium will witness the results of a novel mix of deep rooted legumes and herbs being grown at Clover Hill Dairies as an alternative to the mix of annual ryegrass and kikuyu or paspalum that is traditionally grown on dairy farms in the area.

The research trial, made possible by funding from the Australian Government's Caring for our Country Program began in early 2010 and is a partnership between Clover Hill Dairies and SBSCibus dairy consultant Dr Neil Moss. It is conducted on a 12ha site on our leased property Lemon Grove Research Farm.

COW TO CONSUMER

Clover Hill Dairies dedication to, and promotion of sustainable farming practices extends well beyond the farmgate. We seek to enhance, enrich and promote the whole food and fibre chain from paddock to plate

Beyond best farming practices the Clover Hill Dairies team is committed to:

1. Forging cross community partnerships to secure our social licence to operate and right to farm

On farm a key success factor in the development and implementation of Clover Hill Dairies sustainability plan is our commitment to remain ahead of the curve by examining closely where society is heading and the environmental challenges arising and moving into that space with clear goals and areas of expertise.

We protect our right to farm by actively involving local communities, communicating our journey and involving them in on farm natural resource management activities. We speak to their children in our local schools and employ their youth on our farm.

We actively seek information from industry experts, natural resource management agencies and research scientists about new technologies and concepts that can improve resource use efficiency whilst enhancing environmental outcomes.

We work closely with the landholders on our rural residential subdivision at Clover Hill. We have engaged a professional bush regeneration team to maintain and enhance our high conservation value rainforest country which is home to endangered ecological communities and threated and vulnerable flora and fauna

Our commitment to pursuing environmental excellence whilst improving productivity outcomes is highly valued by the Australian community as witnessed by our 2010 National Landcare Primary Producer Award. Of particular value is our dedication to showcasing sustainable farming practices to government agencies, regional NRM bodies, schools and local government.

In 2012 partner Lynne Strong was awarded the first Bob Hawke Landcare Award. The Bob Hawke Landcare Award celebrates an individual who has been involved in championing the Landcare ethic and inspiring others to take action on their own property or through a Landcare group. This award acknowledges an individual who has demonstrated a remarkable commitment to caring for the land; championing better practices; and gives their time to share knowledge with others so that they too can prosper.

Clover Hill Dairies sustainable practices and innovations are transferable to the wider farming community and to facilitate this we are sharing our learnings with internal and external stakeholders via field days, the media and a series of case studies and fact sheets on our website:

www.cloverhilldairies.com.au/resources.html

2. Encouraging and furnishing opportunities for young people to enter food value chain career pathways

Clover Hill Dairies works with a number of local and international universities in the UK and Canada, opening the farm for work experience, as a case study for honours and PhD theses and as a research facility. Clover Hill Dairies also provides a wide range of opportunities for school students including traineeships and work experience.

The Clover Hill Dairies team are active participants in the Cows Create Careers initiative providing their time and services as industry advocates and mentors. Through Cows Create Careers students, teachers and parents are more aware of the variety of careers that the dairy industry has to offer and more students are entering dairy education pathways and careers.

3. Building lifelong relationships between city consumers and rural providers

To better create connections between urban consumers and farmers, Lynne established the Art4Agriculture initiatives including the Archibull Prize, The Cream of the Crop Competition, Young Farming Champions, Young Eco Champions and the Confidence to Grow Initiative.

Art4Agriculture programs use art and multimedia to engage students in suburban primary and secondary schools in the challenges of housing, feeding and clothing an ever-expanding population with a declining natural resource base. They also train young farmers and natural resource managers to engage with urban audiences, enabling two-way conversations between consumers and those who grow their food and fibre.

See http://www.art4agriculture.com.au/

WHERE TO FROM HERE

The dairy industry in NSW is at a cross roads. Whilst the future may be bright we believe the key to success in the current climate is to consolidate and reduce debt and have the flexibility to move when the time is right.

At 30 years of age Nick is ready to take over the farm. He has many ideas and plans for the dairy with a new vision, team and over time, a new name for the business.

Lynne and Michael, true to their ideals of supporting the next generation to take on leadership roles in the industry, will be leaving the business over the next 12 months.

It’s an exciting time for all of us. We know Nick is looking forward to implementing his vision for the farm.

Michael plans to stay involved in the industry in a part-time capacity assisting Nick on the farm to build up an elite Holstein herd.

Lynne is very excited to be taking the next step in the progression of her industry programs.

Art4Agriculture, Young Farming Champions, Young Eco Champions and the Archibull Prize underscore her passion and being able to dedicate more time to growing these programs was a factor in her deciding to exit our milk business.

Lynne is driven by the need to improve the relationship between farmers and consumers. She is passionate about shifting the way farmers work with, and think about, the supply chain. She believes it is crucial for farmers and consumers to create a joint understanding of agricultural supply chains and their constraints and is confident this will restore value and trust in food and fibre production.

Lynne believes within Australia there is a huge opportunity to build communication and sustainability through the food value chain. This opportunity comes largely from understanding complexities of relationships between the value chain and in particular understanding the needs of our customers and consumers.

For farmers this will mean working beyond traditional boundaries, and challenging the conventional thinking of primary industries and individuals.

For consumers it will mean reflecting on their definitions of value when thinking about Australian grown products.

For the value chain as a whole it will require a paradigm shift in thinking and a collaborative re-allocation of resources and responsibilities amongst all stakeholders.

Achieving the requisite change in mindset that constitutes the first steps on the road to sustainable competitive advantage is the greatest challenge facing farming businesses in Australia today and to help facilitate this Lynne is starting a new business “Farming Ahead of the Curve”.

END OF AN ERA

Over the last 13 years at Clover Hill Dairies we have pushed the boundaries in our endeavour to set up a sustainable farming intensification model that could be embraced by the market and the community. We are proud of our successes and have grown from our challenges and experiences.

We hope the Clover Hill Dairies journey will be a legacy that is etched into the minds of others and the stories they share about us.

Use of legume and herb based pastures in NSW dairy farms

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L. Strong

Dairy farmers, “Clover-Hill” and “Lemongrove” Jamberoo, NSW

- A mix of legumes and herbs was compared to traditional kikuyu and ryegrass pastures on a coastal NSW dairy in 2011 and 2012
- More forage was produced from the legume and herb pasture during the trial period, particularly in year 2 of the study
- Feed quality in the legume and herb blend was superior to both ryegrass in late spring and kikuyu in summer
- Nitrogen inputs were dramatically reduced in the legume and herb pasture
- Paddock selection and regional pasture pests are important considerations when considering pasture varieties

BACKGROUND

Most NSW coastal dairy pastures are based on kikuyu or paspalum in rotation with ryegrass over-sown in the autumn. This system produces forage for most months of year, is generally high yielding, retains drought and weed resilience of kikuyu base, rapidly regenerates after dry early summers following mid-summer rain and is generally resistant to, weeds, wet weather and pugging. However the system has weaknesses in that the winter and spring growth is reliant on ryegrass based pastures that need resowing every year, grass based pastures are highly dependent on nitrogen, most grass pastures are shallow rooted and prone to drought, and the kikuyu component produces only moderate summer feed quality.

Attempts were made 10-15 years ago on many farms to replace kikuyu with perennial rye based pastures. Results were generally poor due to a mix of poor persistence, grass weed invasion, poor summer productivity, endophyte issues and poor growth in dry periods. While improvements in perennial ryegrass cultivars and shifts in understanding in paddock preparation and management of these pastures has improved results in recent years, there is value in exploring other perennial or semi-perennial pasture options that may have different growth curves or may have reduced exposure to the risks, costs and green house emission of grass based pastures relying on high levels of nitrogen input for optimal productivity.

Experience with other farmers in NSW and positive, but unmeasured results from similar plantings at "Lemon Grove" prompted the investigators to seek funding under the Federal Government's Caring For Country program to trial, and quantify some alternative pasture systems based on tap rooted herbs and mixed legumes as an alternative to grass based coastal pastures in NSW.

It was hypothesised that this system would have a much lower requirement for nitrogen, could have a different growth curve compared to grass based pastures, may be able to access deeper moisture and nutrient pools via tap root systems, could have excellent pasture quality in warmer months and as such could form part of a pasture portfolio with a number of risk management and productivity benefits.

MATERIALS AND METHODS

The trial was conducted at Lemon Grove Research Farm, located on the Minnamurra River floodplain just to the east of Jamberoo, NSW. Control and treatment paddocks were identified in December 2010 and soil tests were taken. One paddock was to be identified as the "trial" paddock and was to be prepared for the new pasture; the other "control" paddock was to be farmed as per the rest of the property, retaining its kikuyu base and being sown down to oats and Italian ryegrass in early autumn.

The trial paddock was sprayed with 6L/ha of Roundup Powermax (540 g/L glyphosate (present as the potassium salt)) on 17.2.2011. Pasture trash was mown and removed and the trial paddock sown down to 110kg/ha of Cooba oats on the 19.2.2011. A small area was topped up in early April following flooding in March. Grazing of the oats commenced shortly after and continued until the 5th of August when the paddock was sprayed again with 6L/ha of Roundup Powermax on 5.8.2011. The paddock was then direct drilled with a disc seed with the trial seed mix of:

- 8.5kg/ha Stamina GT6 Lucerne
- 4kg/ha Bulldog red clover
- 1.5kg/ha Kopu II white clover
- 1.5kg/ha Will ladino white clover
- 2kg/ha Tonic plantain
- 2.5kg/ha Puna chicory

The trial paddock was treated with 150ml/ha of Verdict (520g/L haloxyfop present as the haloxyfop-r-methyl ester) selective grass herbicide on the 20.2.2012 to control grass weeds. It was not oversown in the autumn of 2012.

The "control" paddock was sprayed with 200mls/ha of Roundup Power Max on the 1/3/2011 to suppress kikuyu growth and facilitate early planting of a mix of 35kg/ha of Feast II ryegrass and 60kg/ha of Cooba oats. Grazing commenced 16th April 2011. It was resprayed with 225mls/ha of Roundup Powermax on the 16/42012 to suppress kikuyu prior to autumn planting with a similar mix.

Fertiliser was applied to both control and trial paddocks as deemed necessary by the farmer. This included urea, some mixed blended fertilisers and an application of liquid dairy effluent. Pastures were grazed only by the dairy herd and no fodder was conserved during the trial on the two plots. Pasture dry matter was estimated pre and post grazing using a C-Dax towable pasture metre and pasture yields determined. Yield data was validated using pasture cuts and estimation of dry matter during the trial. The nutritive value of the trial and control pastures were tested by NIR at Westons Laboratories, NSW.

RESULTS

Total yield for the first 12 months of trial, including oats, and control pasture was 16413 and 15310 kgs of DM/ha respectively. Total yields in the six months following removal of the oats were 8134 and 6407 kgs DM/ha respectively. Total 2 year yields from trial and control paddocks was 35365 and 25989 kgs of DM/ha respectively. Cumulative yield data is presented in Graph 1.

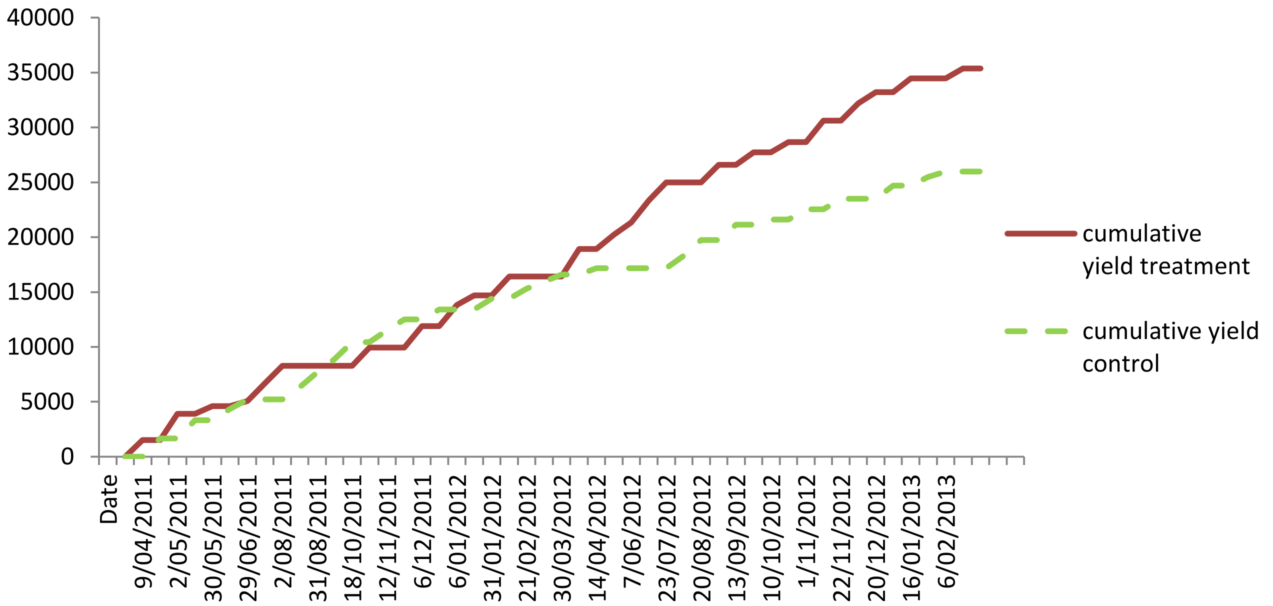

Figure 1: Two year cumulative yield data: herbs and legumes (Treatment) vs kikuyu and ryegrass (control)

In the first year of the trial, 260kg/ha of nitrogen was applied to the trial paddock and 540kg of nitrogen was applied to the control paddock. Of this, 55kg/ha of N and 287kg of N were applied to trial and control paddocks after the planting of the legume and herb blend. In the second year of the study, only 30kg per hectare of N was applied to the herb and legume paddock compared to 188kg of N per hectare in the control.

Feed quality data from two samplings in November and February are presented in Table 1.

Table 1: Comparative feed quality of herb and legume pasture (treatment) vs spring ryegrass (control test 1) and kikuyu (control test 2)

Components:	Treatment Test 1:	Control Test 1:	Treatment Test 2:	Control Test 2:
% 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

DISCUSSION

This farm based trial has provided useful evidence of the potential for alternative pasture systems based on legumes and herbs on coastal dairies in NSW. The trial pastures have provided at least as much dry matter in the first year as the conventional system with the yield data in year 2 being substantially higher in the trial paddock. The trial pasture appears to have performed very well in the autumn of its 2nd year and did not suffer a planting lag as per the conventional system. It also appeared to continue growing very well off a one off significant rain event in October 2012 during what was a very dry spring and summer in the region.

Nitrogen inputs were significantly reduced in the trial compared to the conventional plots with potential here to reduce fertiliser costs as well as nitrous oxide emissions and exposure to volatile nitrogen pricing. Full soil test data is not available at the time of writing.

Feed quality at all times on the trial was excellent with the farmers reporting anecdotal improvements in milk production when grazing trial pastures, particularly between November and March.

Weeds have been troublesome including both broadleaf and summer grass weed invasion in summer of 2012-2013.

These pastures have significant potential for NSW grazing based dairy systems. There has been considerable success with similar systems on the mid north coast and inland areas, however, problems with both stem root nematode and water-logging have been encountered on some properties. Soil characteristics, particularly, potential for poor drainage, underlying weed burdens and regional pasture pathogens need to carefully considered, when selecting alternative pasture systems as part of a pasture "portfolio". However, there is considerable flexibility within both pasture species and cultivars in the group of pasture species under investigation to further explore these systems on a region by region basis. Farmers and scientific organisations can successfully partner to produce useful field based research.

Pasture Management in Two High Performing Automatic Milking Systems

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ABSTRACT

Achieving high voluntary cow movement is one of the major challenges when adopting an automatic milking system (AMS) within a pasture based dairy system. An analysis of two commercial dairy farms with excellent cow flow was undertaken to capture a more detailed understanding of how these farms were achieving regular voluntary cow movement and target milking frequencies. Data was collected throughout January and February 2013 on two farms, located in North-West Tasmania (Farm A) and Western Gippsland Victoria (Farm B). The farms were milking on average 207 and 166 cows respectively, with three Lely A3 robots, 3 way grazing and no irrigation. On Farm A, daily pasture allocation (pre-grazing biomass – 1500) varied significantly ($p<0.05$) from 4 kg DM/cow for block B and C to 2 kg DM/cow for block A, which resulted in a variation in the percentage of feed allocated per hour of active access of 2.2-5.5%. This corresponded with a more uniform milking distribution over a 24 hour period, achieving between 21 and 25 milkings/hour. Farm B's pasture allocation was not significantly different ($p=0.091$) between blocks, however the percentage of feed allocated per hour of active access did vary between 3.3-6.0%. This resulted in more variable milking distribution over a 24 hour period of between 9-22 milkings/hour. Thus, it is concluded that high voluntary cow movement in an AMS can be achieved by varying the quantity and timing of pasture allocation.

INTRODUCTION

Automatic milking systems (AMS) have led a revolution in the global dairy industry over the last 20 years. The development of AMS, driven by a shortage of labour in the 1980s, has eliminated the need for human involvement in the milking process and changed the way that dairy farms operate (De-Konig 2010). Since the first commercial installation in the Netherlands in 1992 (De-Konig 2010), AMS has grown rapidly to now total over 10,000 farms worldwide (Kerrisk and Ravenhill 2010). The majority of AMS farms to date have been housed systems. However, more recently, AMS has been adopted into pasture based systems.

The first Australian installation occurred in 2001 (Kerrisk and Ravenhill 2010), along with the Greenfield Project in New Zealand (Davis *et al.* 2006). This was followed five years later by the Future Dairy project in 2006 (García *et al.* 2007). It is only in the last few years however that the uptake of AMS technology has rapidly expanded, to now incorporate 19 farms across Australia (K Kerrisk 2013, pers. Comm., 29 April). Pasture based AMS farms rely on cows voluntarily trafficking around the farm to achieve efficient machine utilization. In the short time AMS has been incorporated into pasture based systems, it has been identified that pasture allocation is crucial to achieving good voluntary cow traffic.

Lyons *et al.* (2011) showed that providing cows with 3 fresh pasture allocations per 24 hours, rather than the 2 allocations usually seen in pasture based dairy systems, vastly improved the cow traffic around the farm. Offering three allocations provided cows with more incentive to move around the system, as each allocation was depleted more rapidly. This increased the opportunity for cows to be drafted for milking and as a result, increased milking frequency and production. In the Lyons *et al.* (2011) study, the pasture allocations were offered with equal volume of feed and duration. However, it has been observed, that farms with good voluntary cow traffic and robot utilisation vary the amount of feed they offer in each of the three allocations or the time that each allocation is available for. It was therefore hypothesised that high voluntary cow movement can be achieved when the quantity and timing of pasture allocation is varied.

MATERIALS AND METHODS

An observational study of two farms was conducted over an eight week period from January 7th to March 3rd 2013. The two farms were located in North West Tasmania and Western Gippsland Victoria. The Tasmanian farm (Farm A) featured 3-way grazing with supplementary grain fed in the robots and silage supplements provided in the paddock. Cows had active access to each pasture allocation between 1730-0230 (A), 0230-0930 (B) and 0930-1730 (C) hours; this equated to 9, 7 and 8 hour intervals respectively. Average herd size was 207 cows, milked with three Lely A3 Astronaut robots. At 7th March average days in milk was 96 days across the herd. There was no irrigation on the farm.

The Victorian farm (Farm B) also featured 3-way grazing with supplementary grain fed in the robots but on this farm silage was fed ad-lib on a feed pad in the pre-milking area. Cows had active access to the three blocks between 1230-1930 (A), 1930-0500 (B) and 0500-1230 (C) hours; this equated to 7, 9.5 and 7.5 hour intervals respectively. The average herd size was 166 cows, milked with 3 Lely A3 Astronaut robots. At 7th March average days in milk was 189 days across the herd. There was also no irrigation on this farm.

During the eight weeks, data was collected for all pasture allocations every Monday, Wednesday and Friday. Pre- (before cows entered the allocation of pasture) and post- (after the last cow exited the allocation of pasture) grazing compressed pasture height were measured using a Rising Plate Meter (360mm diameter, 315g plate weight) fitted with an electronic counter (Farmworks, Palmerston North, New Zealand). These compressed pasture heights were then converted to pasture biomass using the following formula *height (cm) x 240+500 = kg DM/ha* (Earle and McGowan 1979). Pasture offered was calculated using the equation *pre-grazing – 1500 x area / no. cows = kg DM/cow*, percent of allocation per hour was calculated using the equation (*block allocation / total daily allocation) / block active access time = % allocation/hour.*

Area (ha) of allocated pasture of each allocation in block A, B and C was measured by walking the perimeter of each day's allocations using a handheld GPS. Farmers recorded daily: allocation times, fetch times, number of cows fetched and supplements fed.

Cow milking data was acquired from the Lely milking management system 'Time for Cows (T4C)', data collected from the dairy for each cow included: daily milk yield, milking frequency, grain fed, days in milk and live weight. Each individual cow milking was also recorded with the time, date and milk yield. The number of milkings/hour were calculated for six time periods during the day. These were 0-4 (period 1), 4-8 (period 2), 8-12 (period 3), 12-16 (period 4), 16-20 (period 5) and 20-24 (period 6). Statistical analysis was performed using REML variance components analysis in Genestat 11th Edition. Significant effects are stated at $p<0.05$.

RESULTS AND DISCUSSION

Farm A averaged 25.1L/cow.day and 2.4 milkings/cow.day; whilst farm B averaged 21.7L/cow.day and 2.0 milkings/cow.day. Pasture allocation for each farm is shown in Figure 1. A significant difference was found for the pasture allocated between each block on Farm A ($p<0.05$) but was not significant on Farm B ($p=0.091$).

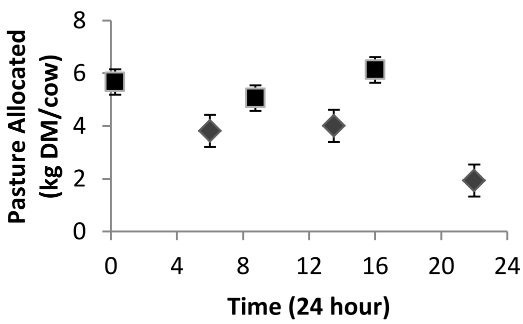

Figure 1: Allocation of pasture (±SE) for each of the three daily allocations (A, B and C) on Farm A (diamond) and Farm B (square). Pasture offered is shown at the median hour for each allocation

When the feed allocation per block (A, B and C) was converted to a percentage of total allocation per hour of active access, Farm A had two larger allocations and one smaller, whilst Farm B featured the opposite (Figure 2). This is because the duration of active access was not a consistent 8 hours between the three blocks on either farm.

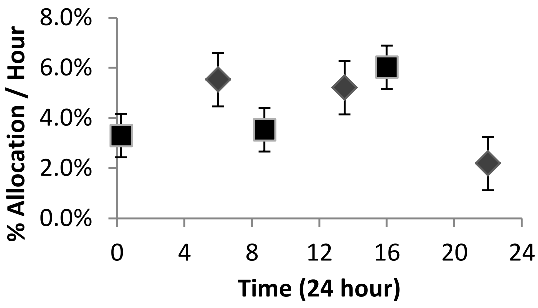

Figure 2: Percentage of total allocation per hour of active access (±SE) for each of the three daily allocations (A, B and C) on Farm A (diamond) and Farm B (square). Pasture offered is shown at the median hour for each allocation

The area allocated for each block was found to be significantly different on both farms (Table 1). Thus, area allocated, along with active access time, are tools used by both farmers to manipulate the feed available in each block.

Table 1: Average area (ha) allocated for each of the three blocks over the 8 week trial

Block	A	B	C	P Value
Farm A	0.32	0.65	0.75	0.001
Farm B	1.32	0.99	0.94	<0.001

A significant interaction ($p<0.05$) between farm and period was found for milkings/hour. Farm A had a more consistent milking distribution, whereas Farm B featured a more variable milking distribution throughout the day. There was also a significant interaction ($p<0.05$) between farm and period for milkings/hour.100cows (Figure 3).

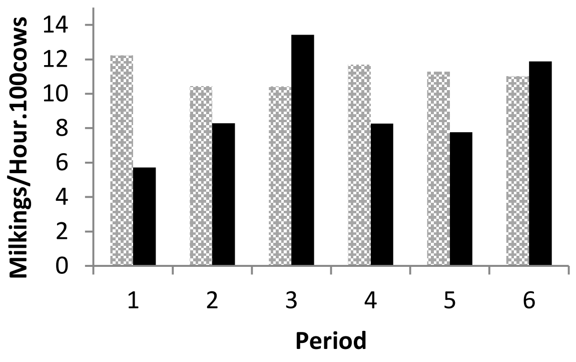

Figure 3: Interaction between farm (Farm A grey, Farm B black) and period on the number of milkings/hour.100 cows (p<0.05)

Over the 8 week trial the average number of milkings/hour on Farm A (23.09) was significantly more than Farm B (15.27). This was expected as Farm B milked on average 41 fewer cows throughout the trial period. Taking this into account, there was still a significant difference ($p<0.05$) between farms, 11.19 and 9.22 milkings/hour.100 cows for Farm A and Farm B respectively.

Both farms were rain-fed and moisture became limiting to pasture growth during the measurement period leading to a significant ($p<0.05$) decline in pre-grazing biomass. As a result, Farm A significantly ($p<0.001$) increased the silage allocation in paddock whilst not significantly (p=204) changing their individual pasture allocation area for each block. Farm B, with silage available ad-lib at the dairy, significantly ($p<0.05$) increased pasture allocation area.

Pasture allocations were found to vary on both the farms in this investigation (Figure 2). Both farms utilised a combination of area and duration to vary the pasture allocation in each of the three blocks. Farm B however was more reliant on the duration of each allocation to achieve this difference, as the initial pasture allocations didn't vary until time was taken into account. The effect of altering the feed allocation between the three blocks had varying effects between the farms.

Farm A had two larger (B and C) and one smaller (A) feed allocation. The smaller feed allocation corresponded with the night time allocation between 1730-0230 hours which being depleted sooner, encouraged the cows to traffic to block B in the early hours of the morning. The peak milking time was in fact during the 0000-0400 hour period, suggesting that offering a smaller amount during this period of the day does increase cow movement and thus help achieve a distributed milking distribution over 24 hours.

In contrast to Farm A, Farm B had two smaller (B and C) and one larger (A) feed allocation. The larger allocation in block A didn't correspond with a greater level cow movement during the day as was expected. The peak milking periods actually occurred during both smaller allocations of blocks B and C; though there were still reduced levels of cow movement during these blocks. It was noted that cows would actively wait for block A to become available, which would explain the higher number of milkings towards the end of block Cs active access period.

CONCLUSION

This study shows that contrary to previous studies, in which 3 way grazing had been divided into three even pasture allocation based on duration and amount of feed (Lyons *et al.* 2011) some farmers are varying one or both of these variables resulting in uneven pasture allocation across 24 hours. The ultimate aim is to achieve a distributed milking pattern and high robot utilisation over a 24 hour period, such as would be found in a housed AMS (Kerrisk 2010). This is achieved through increasing incentive for cows to move during periods of low activity, such as night hours when cows are typically ruminating and resting in a pasture based system (Orr *et al.* 2001).

In conclusion, farmers do vary the quantity and timing of pasture allocation in order to manipulate cow movement on their farms. Further research within a 3 way grazing system should be conducted to understand the optimum timing and allocation of pasture within AMS farms.

This study provides the basis on which this work can be conducted.

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Does Offering Feed Before or After Milking Influence Behaviours of Cows in a Pasture-Based Automatic Milking System?

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ABSTRACT

Voluntary cow traffic allows cows to determine their own daily routine and have a greater degree of control over how much time they spend in various areas of the farm (compared to conventional systems). Feed is known to be one of the greatest motivators for voluntary cow traffic, and has been shown to increase visitations to the milking robot and reduce the time spent in the pre-milking area. The provision of supplementary feeding, a common practice in pasture-based systems, may be a useful strategy in encouraging cows to traffic through the dairy more rapidly, reduce congestion and improve system efficiency. This study investigated the effect of feeding supplement before or after milking at the dairy on cow behaviour within the pre-milking yard. Treatment was found to significantly affect the behaviour of cows (P<0.001). Cows fed after milking were located closer towards the robot entrance, spent less time facing away from the entrance, less time lying in the yard and more time displaying active/alert behaviours (compared to ide/resting behaviours). Further investigations are necessary to determine if differences in behaviours are present between cows that wait a short time versus cows that have extended pre-milking waiting times, and to understand how social hierarchies may impact on the time spent in the yard. This knowledge may result in changes to the way cows are managed at the dairy, with the potential to target social ranking rather than cow production traits to improve traffic through the dairy.

INTRODUCTION

Automatic Milking Systems (AMS) were first introduced into pasture-based farming in 2001 in

Victoria, Australia, and in New Zealand with the Greenfield Project. Since then, interest in AMS in Australia has steadily grown. Currently there are 19 commercial farms operating AMS, including the world's first commercial Robotic Rotary (RR; DeLaval AMR™ - Automatic Milking Rotary, DeLaval, Tumba, Sweden).

Despite the slower uptake in comparison to overseas, where more than 11,000 farms (of which more than 90% are located in Europe) currently operate AMS (Koning 2011), it is widely anticipated that AMS will play an important role in the future of dairy farming in Australia.

AMS is designed to accommodate milkings distributed across the 24 hr day. This can be achieved through the management of voluntary cow traffic, whereby cows set their own daily routine and traffic around the system, including milking, with minimal human interference. Incentives, primarily food, are used to motivate voluntary cow traffic. Feed has repeatedly been shown to achieve increased cow traffic in indoor and pasture-based systems (Halachmi *et al* 2005; Jago *et al* 2007), and is considered the strongest and most reliable incentive available. It is common to provide cows in pasture-based systems with supplementary feed during periods of limited pasture availability. It may be possible that strategic placement of the supplementary feed may influence and increase the traffic of cows through the dairy in a pasture-based AMS without dramatically altering current farming practices.

Large herd sizes common in pasture-based regions (average of 230 and 380 cows in Australia and New Zealand respectively), coupled with factors such as climate and feed type (pasture vs. TMR diet), create different challenges to the management and operation of AMS not previously encountered in indoor systems.

Low ranking cows have been described to wait for longer periods of time in front of the milking unit prior to milking (Lexer *et al* 2009), while greater numbers of cows waiting to be milked in a RR have been linked with prolonged time spent at the dairy (unpub. data).

Additionally, the risk of cows developing lameness and disease from remaining on concrete can be minimised through managing and maintaining good cow traffic at the dairy. Therefore it is important that, with larger herd sizes and the development of technology to accommodate these (Kolbach *et al* 2012), a preventative approach is taken regarding any potential increases in the risk of congestion and subsequent inefficiencies in cow traffic at the dairy.

A study was designed and conducted in September/October 2011 to investigate cow behaviour in the pre-milking yard when cows were fed at the dairy either before or after milking on a 16 milk-point prototype RR. The aim was to characterise the behaviour of cows in the pre-milking yard to assist in understanding whether certain behaviours could be targeted to reduce time spent at the dairy. It was hypothesised that feeding supplement after milking would increase the motivation of cows to be milked (reduce their voluntary time in the pre-milking yard), and reduce the time spent at the rear of the yard and in idle behaviours (including in a lying posture).

MATERIALS AND METHODS

The research was conducted at the Camden AMS farm, located on the Elizabeth Macarthur Agricultural Institute (EMAI; Australia). Ethics approval was granted through the EMAI Animal Ethics Committee prior to the commencement of this study.

A total of 182 cows of mixed breed (predominantly Holstein and Illawarra breeds) and age (30% primiparous) were used in the trial herd. The herd had been managed under voluntary traffic conditions on the prototype RR for more than 7 months prior to this study. Target dry matter intake was set at approx. 23 kg/cow per day, comprised of pasture (approx. 14 kg/cow), supplementary partial mixed ration (PMR; approx. 6 kg/cow), fed on a feedpad (112 m^2) near the RR exit, and up to 3 kg/cow of pelleted concentrate fed adjacent to the feedpad. The PMR was comprised of 44% maize silage, 44% pelleted concentrate and 12% cereal hay.

Water was available at the feedpad and in paddock laneways at all times.

Cows were managed as a single herd, moved around the entire farm system under voluntary cow traffic conditions, and were automatically drafted to treatment location by electronic selection gates. Individuals were randomised into one of two groups (PRE-POST or POST-PRE; as explained below) with groups balanced for days in milk and milk yield (Table 1).

Table 1: Description of treatment and group composition at commencement of study

Description	Group	
	PRE-POST	POST-PRE
Treatment Period 1	PRE	POST
Treatment Period 2	POST	PRE
Number of cows (n)	88	87
Days in Milk*	173±108	176±117
Age (months)*	60±27	65±35
7-day average milk yield (L/cow/day)*	20.89±6.98	20.48±6.64
7-day average MF (milkings/cow/day)*	1.60±0.40	1.59±0.34

Note: values are mean ± SD

** All values are calculated from the trial start date*

The study involved a cross-over design consisting of two periods of 13 days each (7 days habituation, 6 days of data collection), where group name indicated the sequence of treatments received (Table 1). The two treatments were PRE and POST. Cows were granted access to supplementary PMR and concentrates prior to milking when in the PRE treatment, and were given access following milking when in the POST treatment. Prior to the study, cows were trained under both treatment regimes to ensure they were familiar with the required traffic pattern.

On 4 of the data collection days (2 from each period), direct behavioural observations across the 24 hr day were conducted in the dairy. Observers recorded the behaviour of cows in the pre-milking yard (144 m^2), including the posture, orientation, location and activity of cows (Table 2). As cows entered the yard (Entry location), they progressively moved up the yard through the Rear, Middle and Front locations towards the RR entrance (Ramp location). Observations commenced at 07:00, with 15 minute intervals using a scan sampling technique. Observations began at the entrance to the RR and moved through the yard, with each animal observed once per interval.

Table 2: Description of the behavioural observations taken at each 15 minute time interval

Behav. category	Outcome[1]				
Location	Entry	Rear	Middle	Front	Ramp
Activity	Alert	Walk	Ruminate	Idle	Rest
Direction	Front	Left	Rear	Right	
Posture	Stand	Lying			

[1] *Possible observation option within a behaviour category*

Cows were painted with a number (1 through to 182) parallel to their spine along both sides, and across their rump.

Numbers were randomised and used to blind observers to the treatment given, but were clearly visible, enabling the observer to accurately identify individual cows.

Data were analysed using a multinominal logistic Generalised Linear Mixed Model (GLMM) when more than two categorical outcomes existed (orientation, location and behaviour), and a binary logistic GLMM was used when only two outcome categories existed (posture).

Models aimed to determine the percentage of time cows spent exhibiting behaviours in each of the categories in Table 2.

RESULTS

Treatment affected cow behaviour across all behaviour categories (*P*<0.001 for all; Table 3).

Cows in the POST treatment spent significantly less time lying down and tended to spend more time closer to the RR entry (Front and Ramp locations) and less time away from the RR entry (Entry, Rear and Middle locations) than cows in the PRE treatment.

Additionally, cows in the POST treatment were observed to be facing the RR entry more often than cows in the PRE treatment.

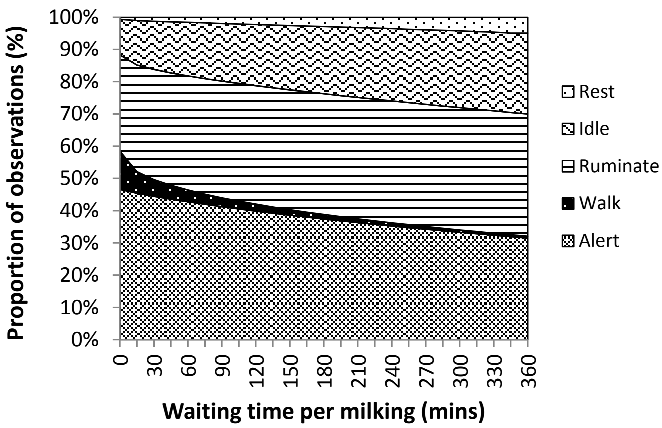

Figure 1: Percentage of Activity[1] in relation to the accumulative waiting time in the pre-milking yard

[1] Legend order directly corresponds to the order of activities in the graph

Table 3: Average number of observations (%) reflecting the proportion of time spent in each behaviour category

Behav. category	Treat.	Outcome[1]				
		Entry	Rear	Middle	Front	Ramp
Location	PRE	0.04[a]	9.35[a]	20.76	24.69[a]	45.16
	POST	0.02[b]	3.69[b]	18.34	28.98[b]	48.97
		Alert	Walk	Rum.	Idle	Rest
Activity	PRE	41.82	1.48	35.48	19.54[a]	1.68
	POST	41.37	1.56	38.69	17.12[b]	1.27
		Front	Left	Rear	Right	
Direction	PRE	69.69	8.13[a]	12.50[a]	9.68[a]	
	POST	74.83	6.16[b]	10.58[b]	8.43[b]	
		Lying	Stand			
Posture	PRE	2.26[a]	97.74[a]			
	POST	0.97[b]	99.03[b]			

[1] Within each behaviour category for the same level of factor (same outcome, different treatment), different superscripts indicate means that are significantly different

The length of time a cow spent in the pre-milking yard per milking visit affected (*P*<0.001) the activity observed, regardless of treatment (Figure 1). As time in the pre-milking yard increased, the proportion of time spent in Idle and Resting activities increased, while Walking and Alert activities decreased. The proportion of time spent Ruminating increased slightly from 0-30 minutes, and remained similar from 30 minutes onwards.

Cows in the POST treatment spent on average 24% less time in the pre-milking yard than cows in the PRE treatment, with significantly different (*P*<0.001) average voluntary waiting times of

76.4±6.3 and 99.6±7.3 minutes respectively. There was no difference in milk yield between treatments throughout the study, with an average production of 19.37 L/cow per day.

DISCUSSION

Results presented in this paper indicated that the strategic placement of supplementary feed at the dairy either before or after milking altered the behaviour of cows in the pre-milking waiting yard. Cows in the POST treatment appeared to demonstrate a greater motivation or interest to be milked than cows in the PRE treatment, with a greater proportion of observations showing cows to be closer to and orientated towards the RR entrance. Additionally, the mean time spent per milking visit in the pre-milking waiting yard was significantly less for cows in the POST treatment. Preference for feeding over milking has been demonstrated previously (Prescott *et al* 1998), while motivation for feed in dairy cattle is well described (Ketelaar-de Lauwere *et al* 1998; Halachmi *et al* 2000). These results support those of the current study, where the use of feed after milking likely stimulated cows to volunteer for milking more readily. Feeding after milking may be a useful strategy to assist in minimising congestion and prolonged time spent on concrete, which may reduce the risk of diseases such as lameness.

Resting is considered an important part of a cow's daily behaviour, comprising between 10 and 12.5 hr per day depending on housing type (Krohn and Munksgaard 1993) and is often performed while lying. However it is not ideal to have cows lying and resting in the dairy in pasture-based systems, as it can not only lead to, but may also instigate in, reduced system efficiency and the development of udder disease and lameness. In the present study, cows in the PRE treatment were observed to be lying and resting significantly more often than cows in the POST treatment. It may be that, due to visiting the feeding area prior to entering the pre-milking yard, PRE cows had already accrued time standing, and therefore exhibited more lying and resting behaviours due to time on concrete rather than a fuller gut. However despite being significantly different between PRE and POST treatments, it is unlikely that the small proportion of lying and resting behaviours will impact on the overall daily time budget of these cows.

Time spent in the pre-milking yard had a significant effect on the activities observed (Figure 1), regardless of treatment. As time in the yard increased, Idle and Resting activities were more commonly observed, while Alert and Walking activities were decreasingly seen. Cattle that spend long periods of time standing, such as in a pre-milking yard, may exhibit lying behaviours in place of other activities normally performed (Albright and Arave 1997), providing a possible explanation as to the results seen in the present study. Interestingly however, rumination time remained fairly constant, with a slight increase after 30 minutes. Rumination, along with eating, can account for up to 60% of a cow's time (Albright and Arave 1997); however it was unexpected that ruminating would remain constant even after being off feed for up to 6 hr. It may be that the sample interval was too lengthy at 15 minutes, recording the behaviour for only a brief portion of that time and future work should focus on smaller sampling intervals.

Whilst results demonstrate the percentage of activities observed as waiting time increases (Figure 1), it does not distinguish between cows that waited a short total time in the yard in comparison to cows that had a prolonged total time in the yard. Further investigation into the data will aim to determine whether fast trafficking cows behave differently than slow cows, in particular looking for the proportion of activities observed across the entire waiting period. Understanding differences in behaviour between fast and slow trafficking cows may assist in developing management strategies, and potentially yard designs, that can target faster traffic in slow cows.

As herd size increases, along with the development of technology to perform large numbers of milkings (Kolbach *et al* 2012), research into cow behaviour and management practices to motivate cow traffic will become increasingly important. At present, there is little known as to how social hierarchy impacts on cow traffic in a pasture-based RR, however it has been shown that lower ranking cows will wait for longer periods of time in front of the milking unit prior to milking (Lexer *et al* 2009). It has often been assumed that cows with higher milk production traffic more readily through an AMS, due to a greater nutrient/dry matter intake. However in the dairy, space is limiting and it may be that social hierarchy plays a strong role in determining the traffic rate of individual cows through the pre-milking yard. Therefore further research into the interactions between social ranking, behaviours and cow traffic is required to better understand how to manage cows in a voluntary cow traffic system, particularly as herd sizes increase.

CONCLUSIONS

Despite the positive response observed when cows were fed in the POST treatment compared to the PRE treatment, there was no difference in overall milk production, allowing a degree of flexibility in the management of supplementary feeding. A smart dairy design would allow for management changes between feeding before or after milking, and facilitate management to meet the targets of the individual operator.

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Exploring labour and capital substitution of adopting automatic milking systems in pasture-based dairy farm

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ABSTRACT

Since commercialisation of the first automatic milking system (AMS) technology in 1992, adoption has significantly increased over the past two decades. It is estimated that more than 11,000 farms worldwide use AMS technology today (De Koning, 2010).

While AMS technology has been widely adopted in countries that have smaller scale farms, only 19 commercial AMS farms are in operation in Australia. Unlike conventional milking systems (CMS), farmers adopting AMS are not expected to have a reduced level of capital investment per cow with larger herd sizes. This is because of the limited throughput per robotic unit. However, recently, the world's first commercial automatic milking rotary (AMR) was installed in Australia designed to accommodate the large scale pasture-based dairy systems prevalent in Australia. The AMR is a type of AMS and has been developed to allow for much higher throughput per hour which makes it suited to moderate to large herds. The AMR can be operated with either batch or voluntary cow traffic and is expected to be more comparably priced to CMS for large herd installations.

Given there are now a number of commercial AMS farms that have been operating for more than 2 years in Australia, there is now commercial data available on the performance of AMS dairy farms, the operational costs, the impact on animal health and the production that is achievable. Having access to commercial data will allow the authors to generate some realistic case studies to evaluate the economic performance of incorporating AMS technology into pasture-based dairy farms.

BACKGROUND

AMS technology was first commercialised in the Netherlands in 1992. One of the main reasons prompting the development of AMS was the rising labour costs experienced in the mid-1970s.

In Europe, milk harvesting represents about 25-35 per cent of the annual labour demand on a dairy farm contributing substantially to the costs of the farm enterprise.

Globally, increasing intensity of dairy farms and rising labour costs have helped to induce widespread adoption of AMS technology on small scale indoor systems, such as those commonly seen throughout Europe.

The increasing intensity and rising labour costs are also characteristics that are increasingly being experienced in Australia's dairy industry. Over the past 30 years there has been a significant increase in the intensity of production systems, although pasture-based systems will continue to dominate Australian dairy systems into the foreseeable future as it represents the lowest cost feed for dairy cows.

In the early development phases, AMS technologies were designed to accommodate small family farms with up to 150 cows. Today, AMS is being adopted by larger farms with more than 500 cows per herd reflecting significant improvements in the technology and increased management skills. Although the rate of adoption on larger scaled farms is significantly lower compared to smaller scale farms.

One of the key reasons for the lower rate of adoption is the higher capital investment cost of AMS compared to conventional milking systems (CMS). In addition, a key challenge of AMS technology for pasture-based systems has been the reliance on the cows to voluntarily and individually enter the milking unit several times a day.

In the literature, the key factors influencing the economic performance of AMS technology compared to CMS are:

- Labour cost savings
- Capital cost of the AMS
- Herd size requirements to allow for profitable adoption
- Impacts on milking frequencies and resultant production per cow
- Throughput per AMS unit
- Adoption period
- Repair and maintenance costs
- Scale efficiencies
- Salvage value

AMS consists of several key modules including the milking stall, teat cleaning system, teat detection system, robotic arm device for attaching the teat cups, control system including sensors, electronic ID readers, concentrate dispenser, system software and the milking machine.

Generally, there are two types of AMS designs including the single stall system and multi-stall system. The single stall system involves one milking robot that serves only one milking stall. This system is able to milk approximately 60 cows several times a day. The multi-stall system consists of either two parallel stalls with a robotic arm located between them or a series of 2-5 stalls with a mobile robotic arm that travels along a rail between multiple stalls.

Recently, the world's first commercial automatic milking rotary (AMR) was installed in Australia designed as a high throughput AMR to allow for economies of scale and reduce the cost per kilogram of milk harvested on the farm. The AMR is also a type of AMS. The AMR aimed to accommodate medium to large herds that are prevalent on the large scale pasture-based dairy systems in Australia and New Zealand.

STUDY AIMS

The literature around the economic impact of adopting AMS technology is widespread in European dairy farming countries and is now well established. However, studies undertaken to date on the viability of AMS technology are of limited use in the Australian context for two key reasons. First, the focus on European countries is less applicable to Australian dairy farmers because of the focus on pasture-based grazing systems in Australia. Second, the economic models have been based on normative models where the benefits of AMS technology were compared with increased costs (Bilj *et al.*, 2007). Adoption of AMS fundamentally alters the whole operational management of the farm system.

Preliminary analysis on the profitability of AMS in Australia suggest that it was unlikely that farmers would achieve as high a return on investment with AMS compared to CMS. Given there is now commercial data available on the performance of AMS dairy farms, the operation costs, the impact on animal health and the production that is achievable the study will generate realistic case studies to evaluate the economic performance of incorporating AMS technology into a pasture-based dairy farm.

In this study, a review of literature will help to document the status of AMS technology globally to date. This includes areas specific to the technology such as milk frequency and yield, capacity, data handling, cow traffic, grazing, labour savings, maintenance and service costs, production impacts, milk quality and animal health etc. Following this, the study will document the experiences of two Australian farms who have commercially adopted AMS technology:

a. Victoria – 3 single box AMS units with Spring calving; and
b. Tasmania – automatic milking rotary with one-third Autumn calving and two-thirds Spring calving.

Given the analysis will be developed based on two real life case studies, the data collected will be specific to the case and therefore are not sampling units in any statistical sense. The types of data represent the physical, financial and management resources available to that farm.

The data sources and assumptions required to develop the whole-farm model include farm size and area, milk price, herd costs, feed costs (including any supplementary feed), shed costs, livestock sales, fixed costs, labour inputs and costs, capital costs, repairs and maintenance costs and milking system running costs.

The analysis will investigate the economic performance of the AMS farms based on its operations during a steady state. Assumptions around the loss of productivity in the adoption period will need to be factored into the analysis.

The study is also expected to investigate the potential adoption options including establishment of Greenfield site, conversion from CMS, and expansion of existing enterprise.

While the study will evaluate the economic performance of the AMS technologies, it will also be clearly identifying the limitations of the study that are unable to be captured in such an economic analysis. This includes non-pecuniary factors such as consistently low somatic cell counts, less stress for cows and farmer, reduced labour management, lifestyle benefits and occupational, health and safety considerations.

Given there has been past studies to quantify the economic performance of CMS, this study will not undertake further quantitative analysis on CMS. However, a discussion comparing CMS and AMS will be provided.

METHOD

The case study method is adopted to analyse two case studies. Yin (2011) defines the method as an empirical inquiry that investigates a contemporary phenomenon (e.g., a "case"), set within its real-world context; especially when the boundaries between phenomenon and context are not clearly evident. One of the key advantages of employing the methodology is the ability to use the results to generalise to theory. The case study will be based on well-grounded theory and sets of propositions – those relating to the application of whole-farm analysis and propositions around labour and capital substitution.

This study applies whole-farm analysis that involves biophysical and economic sub-models that are developed from all prices and costs and biophysical data collected from a case study farm.

This study is interested in how the ratios of labour and capital inputs are combined within a business to meet the objectives of the business owner (that is, the input-input technical relationship). The type of method required to assess whether the use of labour and capital inputs amongst other resources in one way is better than another is whole-farm budgeting. This budgeting technique will be underpinned by economic principles that form the basis of the analysis. These are:

- the principle of comparative advantage in production
- the principle of diminishing marginal returns to extra inputs to production
- the principle of increasing financial risk to capital invested in the farm
- the *probability principle*, which affects all decisions and their outcomes.

The approach gathers key economic, financial and technical information uses a range of techniques, predominantly budgeting and simulation to analyse the information. Budgets are about the future and therefore many of the numbers that are used in the budgets are 'soft'. This is because future yields, prices, and costs are often soft and are formed by opinions. The key to successful budgeting is making good judgements about the items and numbers that go into budgets (Malcolm *et al.*, 2005). A key advantage of this approach is its ability to incorporate risk analysis by estimating probability distributions and the joint probabilities of events and their effect on outcomes.

CONCLUSION

Given there is now greater understanding of AMS in pasture-based dairy systems, the analysis on two real life case studies will make significant contributions to future research and extension activities associated with the introduction of new technologies. In particular, a key addition to the literature will be the analysis of the world's first commercial automatic milking rotary that has recently been adopted right in here in Australia.

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The effects on claw health of feeding supplement to grazing dairy cows on feed pads

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ABSTRACT

A study at Ellinbank was conducted across a lactation to determine the type, prevalence and severity of hoof lesions, and their relationship with locomotion in a herd of 160 grazing cows supplemented twice daily either as a partial mixed ration (PMR) on a feedpad, or as grain in the dairy at milking (Control). A hoof lesion scoring chart was developed to allow more quantitative and repeatable measurements. Three measurements were taken: 1) to provide a baseline measurement in early lactation; 2) 6 weeks after a short-term feeding trial, when various levels of supplement were fed; and 3) in late lactation, when the effects of the short-term trial on hoof health were expected to have resolved. Cows were scored for locomotion (scale 1-5) at each assessment.

Throughout the experiment, it was found that there was no correlation between lesion score and locomotion score. The most prevalent lesions were white line disease, paintbrush haemorrhages, and traumatic bruising. At the second assessment, the odds of a cow having these lesions were significantly higher if they were present at the first assessment. There were no effects of supplement method or level on the prevalence of the major lesion types.

It was concluded that the feeding system did not affect the prevalence of the major hoof lesions. Locomotion scoring was of limited use in the evaluation of hoof health. The findings illustrated the importance of the maintenance of hoof health in early lactation, to minimise progression of lesions and risk of lameness.

INTRODUCTION

Variable rainfall in pasture-based dairying regions can reduce pasture availability and lead to increased cereal-based supplements being fed. A risk with increased grain feeding in dairy cows is sub-acute ruminal acidosis (SARA) and its sequelae, including the effects of inflammation (laminitis) in the hoof (Nocek, 1997). If grain can be fed in a manner that reduces the risk of SARA, farmers could increase the amount of supplement without adversely affecting cows' health and welfare. One suggested approach for reducing these risks may be to offer cows a partial mixed ration (PMR) containing grain and forage, which may reduce the acidotic effects of grain alone (Moran and McDonald, 2010). Although the use of a PMR as a vehicle for feeding high amounts of supplement could reduce the risk of laminitis-mediated foot lesions, it may increase the time cows spend standing and moving on concrete surfaces, exacerbating the risk to cows of traumatic lesions. To investigate these effects, an experiment was conducted to evaluate hoof health and lesion prevalence in grazing cows supplemented with either a PMR on a feed pad or fed grain during milking and forage in the paddock. Our hypotheses were that there would be no difference in locomotion score or presence of common hoof lesions between treatment groups and that there would be a positive correlation between locomotion score and hoof lesion score.

MATERIALS AND METHODS

Cows and treatments

The experiment was conducted at Department of Primary Industries (DPI) - Victoria, Ellinbank Centre (38°14'S, 145°56'E) with the approval of the DPI Agricultural Research and Extension Animal Ethics Committee. A herd of 160 multiparous Holstein-Friesian cows (mean ± sd) 4.7 ± 1.5 years; 561 ± 54 kg; 50 ± 16 DIM were managed as two overall treatment groups. The Control group (64 cows) were fed 12 kg DM/cow/day total supplement consisting of 75% wheat grain fed twice daily in the dairy during milking and 25% pasture silage fed in the paddock. The PMR group (96 cows) were offered a 12 kg/cow/day PMR comprising approximately 39% wheat grain, 20% maize grain, 30% maize silage and 12% lucerne hay (DM basis). The PMR was isoenergetic with the supplement fed to the Control group, and was offered on a feed pad where the PMR cows were confined for 1 to 1.5 hours after morning and afternoon milking, before being moved to a paddock to graze for the rest of the day or night. In addition to receiving their supplement, all cows also grazed a pasture allowance of 14 kg DM/cow/day of perennial ryegrass (*Lolium perenne* L.) pasture, of which they consumed approximately 8 kg DM/cow/day.

For a 28-day period during spring, the cows were further divided within their overall treatment groups into sub groups allocated to a different level of total supplement (8, 10, 12 or 14 kg DM/cow/day). The PMR cows were drafted into their subgroups twice a day on the feed pad, which was subdivided using electric fence tape (Auldist *et al* 2012). Following the 28-day experiment, the cows returned to the original 12 kg DM/cow/day of the Control and PMR diets.

Measurements

Three hoof health assessments were carried out during the lactation. The aim of assessment 1, performed in October, in early lactation (mean 50, range 20-81 DIM) and cows had only been in the Control or PMR groups for 7 to 10 days, was to conduct a baseline measurement, in order to determine the type, prevalence, and distribution of hoof lesions in the herd. The aim of assessment 2, performed in December, 7 weeks after the start of the short term feeding study, was to repeat the measurements during a period that was most likely to coincide with lesions associated with SARA-induced laminitis following increased grain feeding. The aim of assessment 3, performed in March; 18 weeks after completion of the short-term feeding study, was to assess whether there were long-term differences in hoof health between the feeding systems.

At each assessment, all cows were locomotion scored according to the system developed by Sprecher *et al* (1997) using a 5 point scale, with 1 being normal. The locomotion scoring was performed by a veterinarian with experience in the examination of lame cows. The cows were observed one at a time as they exited the dairy, and walked at their own pace along the side of the holding yards.

Within 24 hours of locomotion scoring, each cow was assessed for hind hoof lesions. The cows were restrained using a hoof treatment crush (WOPA B.V., Lichtenvoorde, NL), and each hind foot was elevated in turn. The foot was cleaned with water, and the surface layer of the sole (approximately 1 mm) removed using an electric angle grinder fitted with a hoof trimming disc (Roto-clip, Utah, USA).

A different veterinarian from the one who assessed locomotion assessed the presence of lesions and graded for severity those lesions likely to be most common in Victorian conditions; paintbrush haemorrhage (PBH), white line disease (WLD) and traumatic bruise. The chart developed for the recording of each assessment is shown in Figure 1.

Both PBH and bruising were given a grade 1 to 3. The location of each lesion was recorded according to the zones of the sole, shown on figure 1. The presence of yellow horn was noted (Y). White line disease was not characterised by zone (as by definition the white line occupies zones 1 and 2), but was graded 1 to 4, The lesions that were not graded for severity were just marked as present or absent, as shown in figure 1. All cows were tested for pain with hoof testers and graded as no pain, moderate pain or severe pain.

Statistical Analysis

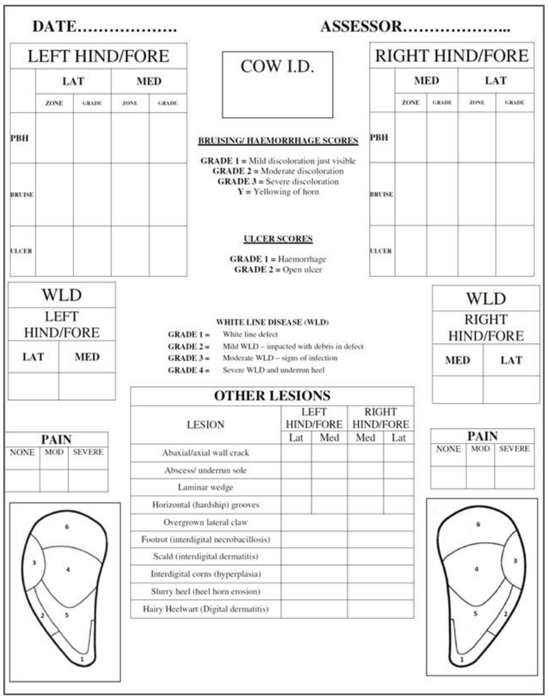

Figure 1: Hoof lesion scoring chart

For assessment 1, the data were summarised as the percentage of cows with the different categories of hoof lesions. The percentage of cows with the lesions PBH, WLD or bruising in a lateral hoof compared with a medial hoof was assessed using McNemar's test for paired proportions. A total lesion score for each cow was calculated, by adding the scores for each lesion recorded for a cow. For subsequent assessments, only cows that had been present at assessment 1 were included in the analysis. For assessment 2 and 3, the data were analysed using logistic regression for differences between feeding method (and feed rates (linear) at assessment 2) for the presence of the lesions WLD, PBH and bruising (≥ grade 2). Differences between groups for the presence of heel erosion and yellowing of hoof horn were also assessed.

A covariate using these outcomes (at assessment 1) was included. An odds ratio >1 indicated an increased odds of the lesion at assessment 2 or 3 when present at assessment 1, compared with being absent at assessment 1. The correlation between total lesion score and locomotion score at each assessment was examined using Spearman's rank correlation coefficient. Stata 12.1 (StataCorp, College Station, TX) was used for all analyses. A two-tailed *P*-value < 0.05 was considered to be statistically significant.

RESULTS

From assessment 1; the lesions with the highest prevalence were WLD, PBH and traumatic bruising. The prevalence of the most common types of lesions is presented in Table 1. The proportion of 160 cows affected by lesions was greater (P <0.001) in the lateral than in the medial hoof for each of WLD (lateral 89.4%, medial 34.4%), PBH (lateral 80.6%, medial 36.3%) and bruising (lateral 31.9%, medial 10.6%). Spearman's rank correlation coefficient demonstrated no correlation between total cow lesion score and locomotion score. (r_s = 0.036; P = 0.65; n=160).

From assessment 2; feeding group (PMR vs. Control) was found to have no effect on WLD, PBH or bruising. Feeding group was found to have an effect on yellow horn and heel erosion, whereby PMR cows were more likely to have these lesions than Control animals (Table 2).

Table 1: Most common hoof lesions in a research dairy herd in South Gippsland in early lactation (n=160)

Lesion type	% cows (assessment 1: n=160)	% cows (assessment 2: n=158)	% cows (assessment 3: n=145)
WLD (worst score) grade 1	58.8	49.4	54.5
WLD (worst score) grade 2-4	31.2	12.7	9.7
PBH (worst score) grade 1	55.6	74.7	69.0
PBH (worst score) grade 2-3	25.0	9.5	9.7
Bruising (worst score) grade 1	18.8	27.9	10.3
Bruising (worst score) grade 2-3	16.9	7.0	2.1
Yellow horn	7.5	32.3	6.2
Digital dermatitis	11.9	6.7	12.4
Heel horn erosion	15.6	23.4	7.6

Table 2: Effect of feeding method on the prevalence of hoof lesions in a research dairy herd in South Gippsland at assessment 2 in mid-lactation

Lesion	PMR (n=94)	Control (n=64)	*P* value
WLD (≥grade 2)	11.7%	14.1%	0.60
PBH (≥grade 2)	12.8%	4.7%	0.16
Bruise (≥grade 2)	6.4%	7.8%	0.66
Heel erosion	29.8%	14.1%	0.049
Yellow horn	41.5%	18.8%	0.003

Feed level (from the short term feeding trial) was found to have no effect on any of the lesion types; (WLD ≥ grade 2, P = 0.33; PBH ≥ grade 2, P = 0.051; bruise ≥ grade 2, P = 0.15; heel erosion, P = 0.55; yellow horn, P = 0.64).The odds ratio of a cow having a lesion (≥ grade 2 for WLD, PBH and bruise) at assessment 2 (if that lesion was already present at assessment 1) was 7.2 for WLD (P <0.001), 1.7 for PBH (P = 0.35), 4.8 for bruise (P = 0.016), 4.6 for the presence of heel erosion (P = 0.001) and 7.0 for the presence of yellow horn (P = 0.007). Spearman's rank correlation coefficient showed no correlation between total cow lesion score and locomotion score (r_s = 0.11; P = 0.16; n=158).

From assessment 3; fending group (PMR vs. Control) had no effect on prevalence of WLD, PBH, bruising or heel erosion. Feeding group was found to have an effect on yellow horn, which was less prevalent in PMR cows (0%) than Control animals (15.5%). The odds ratio of a cow having heel erosion at assessment 3 if it was present at the first assessment was 9.4 (P = 0.001). For all other lesions, the effect on the odds ratio of a cow having the lesion at assessment 3 was not significant. Spearman's rank correlation coefficient showed no correlation between total cow lesion score and locomotion score. (r_s = 0.15; P = 0.074; n=145).

DISCUSSION

The key findings of this experiment were that the most prevalent hoof lesions in this herd were WLD, PBH and bruising, and the presence of a lesion in early lactation increased the risk of a cow having lesions at subsequent assessments. There was no difference in the prevalence of the major lesion types between feeding systems, or due to the amount of supplement in mid lactation. There was no association between total cow lesion score and locomotion score.

There have been few recent studies investigating the prevalence of various lesions in cows in the pasture-based dairying systems typically found in Australia. The type of lesions most prevalent in intensively managed herds more common in the Northern Hemisphere are sole ulcers and lesions such as WLD and double sole, which have been associated with laminitis (Nocek, 1997). In the first two assessments of the current experiment, two of the lesions associated with laminitis (PBH, WLD) were the most prevalent. Although inflammation of the laminae may have been present, the question of aetiology remains; whether this was a result of the internal inflammatory processes associated with the early lactation period, or due to inflammation within the hoof induced by wet conditions, softening of the sole and then percussive trauma. A total of 150.6 mm of rain was recorded for August 2010 when most of the cows calved, compared with the mean rainfall for August of 102.3 mm (Bureau of Meteorology, 2012).

In a survey in the Western District of Victoria, Harris *et al* (1988) found the most common types of lesions to be excessive wear and bruising, and did not consider that at that time laminitis was an issue. A survey in the Macalister Irrigation District of Victoria (cited by Vermunt *et al*, 2010) found that lesions associated with laminitis were far more prevalent than reported by Jubb and Malmo (1991). More recent studies (Lawrence *et al*, 2011), found WLD and traumatic sole injury to be the most prevalent lesions in New Zealand. In the current study yellow horn and heel erosion were more prevalent in PMR cows at the second assessment. The increased prevalence of yellow horn, in these cows may have been because they had previously been involved in an experiment in which they were drafted twice daily into their experimental groups on the feed pad and this may have contributed an effect of management. Heel erosion is usually associated with housed cows, and exposure to dirty underfoot conditions, however the surface of this feedpad was dry, so the increase in heel horn erosion in the PMR group was a surprising result. It may be that the benefits of the formulation of the ration for the PMR cows may have been offset by the wet conditions at pasture. By assessment 3, PMR cows had been managed as a whole group for 18 weeks. This final assessment, conducted at a stage of lactation where any lesions resulting from the short term experiment should have resolved, showed that for PBH, bruise and heel erosion, there were no significant differences between feeding systems, but that for yellow horn, the PMR cows were at a significantly less risk of having the lesion than Control cows. Digital dermatitis was present in 6.7 – 12.4% of the herd across the assessments, and this has not been reported as a significant finding in other surveys conducted in Australasia, although it is a widely recognised cause of lameness in the Northern Hemisphere.

The locomotion score of the cows did not correlate with total lesion score at any assessment. Locomotion scoring may have limitations, especially to demonstrate differences between treatment groups in a research herd. Although Thomsen *et al* (2012) found locomotion score was a predictor for lesions, other authors have found poor correlation between locomotion score and hoof lesions (Flower and Weary, 2006; Tadich *et al*, 2010). Lesion scoring may enable a more detailed analysis of hoof health, but if lesions are not accompanied by pain, the presence of a lesion, without pain or lameness may not mean that the welfare of the cow is compromised. It may however predispose that cow to more severe lesions and lameness later in lactation. It remains important therefore to combine several measures of hoof health (locomotion, pain and lesion scoring) in order to enable a thorough assessment.

CONCLUSIONS

It was concluded that in a pasture-based system, feeding cows their supplement in the dairy or as a PMR on a feed pad had no effect on the prevalence of the common lesions WLD, PBH or bruising. Increased levels of supplement did not result in an increase of the prevalence of the lesions associated with SARA. The management of cows in the early lactation period is extremely important for the hoof health through the rest of the lactation, and it may be advisable for the hooves of a subset of cows in a herd to be examined regularly for lesions, along with observation of locomotion.

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Effect of Extent and Rate of Wilting on Nitrogen Components of Grass Silage

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ABSTRACT

Wilting grass prior to ensiling generally increases dry matter (DM) intake, but the effect of wilting on animal performance is still poorly understood. This study focused on effects of the extent and rate of wilting on nitrogen (N) components of grass silage. Meadow grass was wilted to 4 DM contents (200, 350, 500, 650 g/kg) at 2 different rates (fast, slow), totalling 8 silages. Metabolisable protein was estimated using the modified Hohenheim gas test. Ruminally undegraded feed crude protein (RUP) was measured using an in situ technique. Non-protein-N (NPN) was measured to examine the extent of protein breakdown. Amino acid composition prior to and after rumen incubation was also investigated. Fast wilting and high DM content (DM 650 g/kg) increased metabolisable protein content and decreased rumen degradability. Increased metabolisable protein (MP) may improve milk protein yield, while reduced degradability may reduce nitrogen lost from urinary excretion. Non-protein-N decreased with increasing DM and fast wilting. The higher RUP content from both DM-650 silages lead to higher total amino acid content after rumen incubation. Treatment also influenced the amino acid composition of the ensiled material, but the composition after rumen incubation was similar across treatments. This indicates that wilting mainly affects the quantity of amino acids reaching the intestine, rather than the quality. Conclusively, fast wilting enhanced protein quality of grass silage at all measured levels of DM. High DM also improved protein quality, however, under practical conditions ensiling at such high DM may lead to spoilage.

INTRODUCTION

Wilting grass prior to ensiling is common practice in many countries. The main reasons for wilting are to improve fermentation quality (Marsh 1979) and to reduce environmental pollution and nutrient loss through effluent runoff. Wilting generally also increases DM intake (Dawson *et al* 1999; Wright *et al* 2000; Huhtanen *et al* 2007) though this does not always translate into improved animal performance. Despite a large number of studies comparing wilted and unwilted silage, the effect of wilting on animal performance is still poorly understood. Generally, responses in terms of DM intake and performance of both dairy and beef cattle to wilting are mainly a reflection of the fermentation quality of unwilted silage relative to its wilted counterpart (Wilkins 1984). Ammonia-N concentration is particularly influential on DM intake, with higher ammonia decreasing intake (Wright *et al* 2000). In a review of the literature, Wright *et al* (2000) also established that responses in DM intake and animal performance are related to the extent and rate of moisture loss in the field. Taking all of this into consideration, it is important to gain a better understanding of the effects of wilting on the nutritional components and chemical composition of grass silage. This study has focussed on the effect of extent and rate of wilting on N components.

METHODS

Meadow grass was wilted to 4 concentrations of DM (200, 350, 500 and 650 g/kg fresh matter) at 2 rates of moisture loss (fast and slow), totalling 8 silages. All silages were made from the same parent material (pasture: approximately 0.85 perennial ryegrass, 0.08 legumes and 0.07 herbs, second harvest, heading) from the 2008 harvest in Germany. The grass was subdivided and either wilted thinly spread on black plastic in the sun (fast; F) or on white plastic in the shade (slow; S) until targeted DM was reached. Wilting times of each treatment are in Table 1. For DM-350, 500 and 650 g/kg the difference in wilting time between fast and slow was 24 h. For DM-200 the difference was only 2 h and, due to insufficient material, these samples were not analysed for MP. Weather conditions during the wilting period were sunny and hot, with maximum temperatures around 30°C over the 2 days required to achieve all treatment DM targets. Upon reaching the desired DM the grass was chopped at a 20 mm setting and ensiled in triplicate, without additives, in 1.75 litre glass jars. Ninety days fermentation was allowed in a temperature controlled storage room at 25°C. The treatments will be accordingly referred to as: F-200, S-200, F-350, S-350, F-500, S-500, F-650 and S-650. An intensive examination of N components was performed including analysis of: MP via the modified Hohenheim gas test (Steingass *et al* 2001, Edmunds *et al* 2012a), RUP via an in situ technique, where samples were incubated in the rumen of cannulated cows (Edmunds *et al* 2012b), NPN using Tungstic acid, and amino acid composition both prior to and after rumen incubation.

RESULTS AND DISCUSSION

Results of the proximate analysis of feed quality and exact DM at ensiling are presented in Table 1. Treatment had no effect on crude protein (CP) content. Neutral detergent fibre (NDF) increased with increasing DM content and ME decreased by 1 MJ in both DM-650 silages. Wilting speed had no effect on any of the aforementioned components and there was no interaction with DM. It is important to note here that the lack of change in CP with treatment does not mean protein was not affected. Crude protein is defined as the total N in a feed. Under these experimental conditions a loss of N was not expected because grass was ensiled in glass jars and effluent runoff was not a factor. As will now be demonstrated, the characteristics of N can change without affecting total CP.

Table 1: Wilting time (h), DM content (g/kg) at ensiling, crude protein (CP), neutral detergent fibre (NDF) (all in g/kg DM) and metabolisable energy (ME, MJ/kg DM) of silages wilted to various DM contents at two rates (R) of moisture loss (F = fast, S = slow)

Treatment	Wilting time	DM	CP	NDF	ME
		-----------silage-----------			
F-200	3	194	188	417	11.0
S-200	5	193	189	406	11.2
F-350	7	381	189	434	11.2
S-350	31	373	191	444	10.8
F-500	9	499	186	450	10.8
S-500	33	466	195	436	10.8
F-650	26	692	179	484	10.1
S-650	50	669	191	472	10.0
DM			NS	*	*
R			NS	NS	NS
DM x R			NS	NS	NS

*NS not significant, * P < 0.05*

A more useful measure of feed protein value than CP is MP, which is defined as the supply of amino acids from both microbial CP and RUP (also known as UDP or bypass protein) that is digested in the intestine. This is the direct supply of amino acids to the cow and can be converted into muscle, milk protein and energy. Both wilting extent ($P<0.05$) and speed ($P<0.01$) affected MP content (Figure 1). In treatments F-350, 500 and 650 g/kg, MP was approximately 10% higher that slow-wilted treatments. There are 2 probable explanations for this effect:

1) fast wilting generally results in a better preservation of substrates, e.g. water soluble carbohydrates, which are required for microbial protein synthesis,

2) slow wilting leads to a higher level of protein degradation in the field, which decreases the proportion of RUP and increases the proportion of NPN, which is poorly utilized by the animal if in oversupply.

This latter effect is clearly demonstrated in Figures 2a and 2b. Figure 2a describes changes to RUP across treatments. At all levels of DM fast wilting resulted in higher RUP. As is clear from Figure 2b, the opposite is true for NPN, meaning a higher proportion of true protein remained in fast-wilted treatments. Rumen degradability of silage protein is generally high due to unavoidable breakdown of true protein during wilting and fermentation. Our aim, therefore, is to minimise this breakdown and decrease rumen degradability of silage. This study shows that we can achieve this, to some extent, through fast wilting. It also shows that wilting to 650 g/kg DM is even more effective in reducing protein degradability. However, successfully ensiling such dry grass is difficult under normal circumstances so the more important effect here is the decrease in degradability and increase MP with fast wilting.

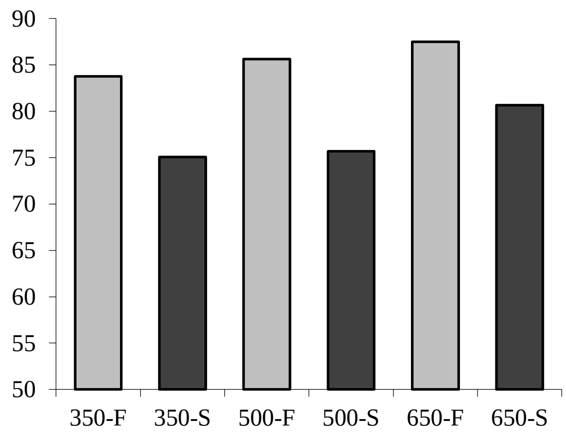

Figure 1: Effect of dry matter and wilting speed (fast - F, slow - S) on metabolisable protein supply (g/kg DM)

The amino acid profile of the silages was compared to that of unensiled grass and the effect of ensiling altered the profile (Edmunds *et al* 2013). The amino acid profile was also analysed after rumen exposure and these effects roughly mirrored the effects of ensiling.

Thus, it was observed that the net effect of ensiling and rumen exposure on the amino acid profile was not greatly influenced by treatment and the total changes were similar to that of a fresh, unensiled grass of similar botanical composition.

This implies that the difference in amino acid composition between the original material and RUP are due to rumen exposure and not ensiling and that the main effect of ensiling is in the final supply of amino acids to the duodenum.

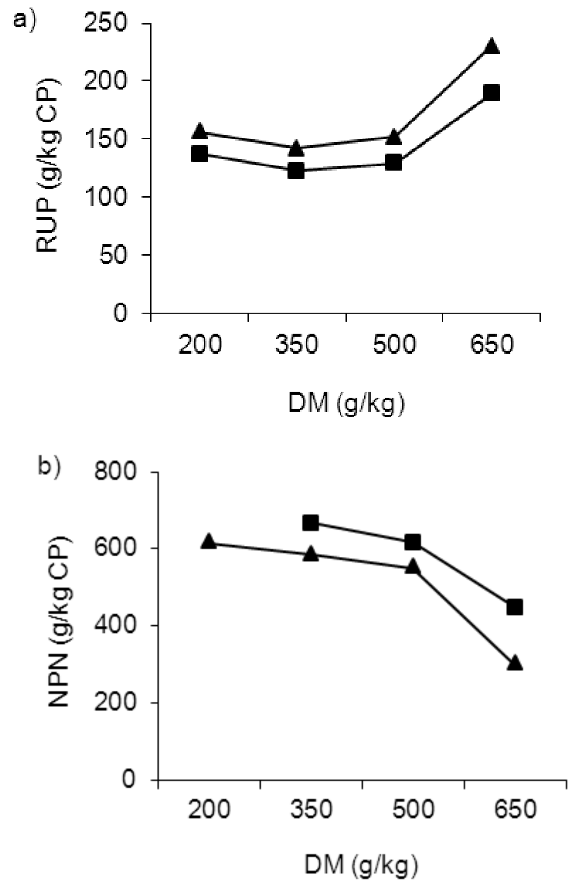

Figure 2: Effect of dry matter (DM g/kg; x-axis) at ensiling and wilting speed (▲ fast, ■ slow) on:

a) Ruminally undegraded crude protein (RUP) (above)

b) Non-protein N (NPN) (Edmunds *et al* 2013) (above)

CONCLUSIONS

Fast wilting increased MP content and decreased RUP and NPN at all measured levels of DM. Based on this, farmers are advised to aim for current recommended optimal DM for ensiling, depending on their chosen methods (stack, bales or tubes) but avoid wilting for prolonged periods of time. It may be advantageous to ensile grass at a slightly moister DM at the end of the day, rather than wilting grass over-night and into the following day, provided the grass is not too wet to ensile.

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Mid-lactation Response of Cows Grazing Pasture Mixtures Containing Perennial Plantain, White Clover, and Ryegrass

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ABSTRACT

Incorporation of the perennial species plantain (Plantago lanceolata) and white clover (Trifolium repens) into pasture based dairy systems has the potential to improve the supply of highly digestible forage during times when perennial ryegrass (Lolium perenne) has low growth rates or poor nutritive value. The objective of this study was to determine the effect of grazing cows on pasture swards containing mixtures of plantain, white clover, and perennial ryegrass on milk production and energy and nitrogen status during mid-lactation. Four pasture sward treatments were assessed; perennial ryegrass monoculture; white clover and plantain mixture; perennial ryegrass, white clover and plantain mixture; and spatially adjacent monocultures of perennial ryegrass, white clover and plantain. Pasture swards were grazed with 4 replicate herds, balanced for age, breed, days in milk, and production to date. Each replicate was allocated 20kg DM/cow/day of pasture from their treatment sward. Liveweight, body condition score, milk yield, milk composition along with blood metabolites (non-esterified fatty acids (NEFA), beta-hydroxybutyrate (BHB) and blood urea nitrogen (BUN)) were used to assess how treatments were affecting cows in mid-lactation. There was no effect from treatment swards on milk yield between treatments during the response period. NEFA and BHB indicated no signs of negative energy balance in all treatments. BUN concentrations were equal to or higher than perennial ryegrass for the treatments containing plantain and white clover. It was concluded that the incorporation of plantain and white clover into pasture based systems will have no negative effects on production or energy and nitrogen status during mid-lactation.

BACKGROUND

Pasture is the main and cheapest source of feed for dairy farms in Tasmania. The low cost and reliable production of pasture in Tasmania provides a competitive advantage to Tasmanian dairy farms compared to their mainland and international counterparts (DairyTas, 2010). Perennial ryegrass (*Lolium perenne*) is the most common dairy pasture species grown on Australian farms (Fulkerson *et al.*, 2008). While this species is productive and relatively simple to manage, it has limitations as a sole dairy feed due to its seasonal growth pattern and corresponding changes in nutritive value. Identifying other perennial pasture species that complement perennial ryegrass during periods of low growth or low nutritive value will allow dairy farms to improve productivity, without relying on high levels of supplementation.

For this study, plantain (*Plantago lanceolata*) and white clover (*Trifolium repens*) have been proposed as species that may be complementary to perennial ryegrass. Plantain is a forb that has very palatable leaves and can grow on a wide range of agricultural soils (Stewart, 1996). White clover is a legume already commonly sown as a component of dairy pasture and has been shown to support greater levels of milk production when incorporated at 55 to 65% of the pasture base (Harris *et al.*, 1997). For these two species to complement perennial ryegrass pasture swards, industry will need to know the potential milk production that can be obtained from the inclusion of these two alternative pasture species. Furthermore, when incorporated into the pasture feedbase, issues such as palatability and energy and nitrogen status obtained by cows from grazing these species need to be determined.

The aim of this study was to assess the cow's response to the inclusion of plantain and white clover to the pasture sward by analysing her milk production and energy and nitrogen status.

MATERIALS AND METHODS

The study was conducted at the Tasmanian Institute of Agriculture Dairy Research Facility, Elliott, Tasmania (41.08 S 145.377 E) during January 2013. During the trial mean maximum temperature was 20.2°C and mean minimum temperature 10.4°C. One rain event occurred on day 4, with a total of 6.8 mm.

Treatments

The experiment comprised of 4 pasture treatments; a ryegrass monoculture, a ryegrass, clover and plantain mixture, a clover and plantain mixture, and spatially adjacent monocultures (SAM) (ryegrass, clover and plantain as three strips, i.e. not mixed). The mean botanical composition of each of the treatment swards are shown in Table 1. From day 1 through to day 5, cows grazed dry land paddocks, while from day 6 onwards cows grazed irrigated paddocks exclusively. Each of the 4 pasture treatments were grazed continuously for 16 days by 4 replicate herds containing 4 cows each. Pasture was allocated to cows at 20kg DM/cow/day and given in two equal grazing breaks, immediately following the morning and evening milkings. Pasture allocation was determined using a rising plate meter (Earle and McGowan, 1979) calibrated to each pasture species.

Cows

Sixty four dairy cows in mid lactation (164 ± 3 DIM) (4 treatments x 4 reps x 4 cows/rep) were balanced for age, milk yield, weight and breed. Each herd of 4 cows was randomly allocated to 1 of the 16 herds for the duration of the treatment period. At the beginning of the experimental period, all cows were administered a slow release rumen capsule providing 0.32g monensin daily (avg) as a preventative for bloat. Cows were milked twice a day at 0600 and 1500 hours.

Table 1: Mean (±SEM) botanical composition of the 4 pasture treatments

	Botanical Composition (% DM)			
	Ryegrass	Clover	Plantain	Other
Dry Land				
C and P	0 ± 0	3 ± 2	80 ± 9	17 ± 7
R and C and P	92 ± 4	0 ± 0	5 ± 4	3 ± 2
Ryegrass	98 ± 2	0 ± 0	1 ± 1	1 ± 1
SAM Strips				
Ryegrass	98 ± 1	0 ± 0	0 ± 0	2 ± 1
Clover	5 ± 5	41 ± 13	10 ± 4	44 ± 13
Plantain	1 ± 1	1 ± 1	80 ± 10	18 ± 10
Irrigated				
C and P	0 ± 0	8 ± 2	86 ± 2	6 ± 1
R and C and P	80 ± 5	4 ± 2	14 ± 5	2 ± 1
Ryegrass	99 ± 0	0 ± 0	0 ± 0	1 ± 0
SAM Strips				
Ryegrass	98 ± 1	1 ± 1	0 ± 0	1 ± 0
Clover	1 ± 1	71 ± 8	4 ± 1	24 ± 8
Plantain	1 ± 1	8 ± 7	78 ± 15	13 ± 7

* *Other = broadleaf weeds and other grasses*

SAM = spatially adjacent monocultures

R and C and P = Ryegrass, Clover and Plantain

Measurements and Sampling

Measurements were taken over three periods; Pre-treatment, Acclimation Phase (days 1 - 12) and Response Phase (days 13 - 16). Blood samples were collected after morning milkings from each cow 4 times; day -4, 3, 14 and 16. Blood samples were collected via coccygeal venipuncture using vacutainer tubes containing sodium heparin. The collected blood was centrifuged (1,125g; 10 mins; 4^{o}C) and plasma collected and frozen at -20^{o}C until laboratory analysis. Plasma samples were analysed for blood urea nitrogen (BUN), non-esterified fatty acid (NEFA), and beta-hydroxybutyrate (BHB). Analysis of bloods was done at the Western Australia Department of Agriculture and Food Animal Health Laboratory, South Perth.

Milk yield data was collected daily using milk meters (DeLaval milking point controllers MPC680) and milk quantity recorded using DeLaval's Alpro Herd management System, Alpro Windows 7.00 version 7.00.001 (released Sep 2011). Milk samples from both morning and evening milkings were collected on seven days during the experiment; days -1,4, 9, 13, 14, 15 and 16. Milk samples were analysed for fat and protein. Analysis was undertaken by TasHerd, Hadspen, Tasmania. Pre-treatment milk composition was taken from a December herd test (day -26) due to an issue with feeding, that affected all treatment groups except the perennial ryegrass treatment, that occurred on day -4 that was not detected and corrected until day 2, therefore milk composition samples taken from day -1 have been omitted. Pre-treatment milk yield was for day -5.

Body condition score was assessed (DNRE, 2002) concurrently with blood collection. Cow's liveweight was measured daily as they exited the dairy by walking over the automatic in-race scales (DeLaval automatic weigh system AWS100).The data was analysed using the mean of the replicates and differences determined based on the standard error of the means.

RESULTS

There were no significant differences between treatments in respect to milk yield or blood NEFA levels during the response period (Table 2). The ryegrass treatment recorded the highest average milk fat percentage during the response period, whilst the clover and plantain mixture treatment recorded the lowest average milk fat percentages during this period (Table 2). The ryegrass, clover and plantain mixture, and SAM treatments all recorded similar milk fat percentages (Table 2).

Cows grazing the ryegrass and the ryegrass, clover and plantain mixture recorded higher milk protein percentages than cows grazing on the SAM and clover and plantain mixture (Table 2). The ryegrass, clover and plantain mixture was the only treatment that showed a change in milk protein percentage between pre-treatment and the response phase (Table 2), but this may be a result of the pre-treatment sample being taken long before the commencement of the study.

BUN concentrations in the response period differed between treatments, with the SAM and clover and plantain treatment cows having the higher BUN concentrations (Table 2). The ryegrass, clover and plantain, and ryegrass treatments had the lower BUN concentrations during the response period (Table 2).

The SAM and ryegrass, clover and plantain mixture and ryegrass treatments had the highest BHB levels, while the clover and plantain treatment had the lowest (Table 2). All treatment groups saw an elevation in BHB concentration, between the pre-treatment and response period. This elevation had occurred early (day 3) in the trial during the acclimation period (Table 2).

Table 2: Mean (± SEM) response in milk and blood metabolites of dairy cows in mid-lactation grazing 4 pasture swards (Clover and Plantain; Ryegrass, Clover and Plantain; Pure Ryegrass; and spatially adjacent monocultures) over three periods (Pre-treatment; Acclimation phase; and Response phase)

	Milk Yield (L)	Fat (%)	Protein (%)	BUN (mmol/L)	NEFA (mmol/L)	BHB (mmol/L)
Clover and Plantain						
Pre Treatment	19.2 ± 0.6	4.01 ± 0.14	3.04 ± 0.05	3.35 ± 0.15	0.13 ± 0.02	0.50 ± 0.05
Acclimation	19.8 ± 0.6	4.16 ± 0.09	2.99 ± 0.04	3.48 ± 0.15	0.07 ± 0.01	0.85 ± 0.05
Response	19.8 ± 0.9	3.83 ± 0.05	3.07 ± 0.02	5.16 ± 0.22	0.12 ± 0.02	0.61 ± 0.04
R and C and P						
Pre Treatment	19.0 ± 0.8	4.16 ± 0.23	3.09 ± 0.04	3.58 ± 0.23	0.21 ± 0.04	0.52 ± 0.05
Acclimation	19.7 ± 0.7	4.02 ± 0.27	3.08 ± 0.04	4.34 ± 0.20	0.10 ± 0.02	0.77 ± 0.05
Response	21.0 ± 0.7	4.34 ± 0.08	3.18 ± 0.03	4.44 ± 0.18	0.10 ± 0.01	0.70 ± 0.03
Ryegrass						
Pre Treatment	19.7 ± 0.7	4.64 ± 0.12	3.14 ± 0.05	3.39 ± 0.18	0.13 ± 0.03	0.54 ± 0.04
Acclimation	21.7 ± 0.7	4.43 ± 0.14	3.18 ± 0.04	5.00 ± 0.15	0.12 ± 0.03	0.63 ± 0.03
Response	20.6 ± 0.7	4.61 ± 0.08	3.17 ± 0.03	4.18 ± 0.20	0.10 ± 0.01	0.69 ± 0.03
SAM						
Pre Treatment	19.5 ± 0.8	4.36 ± 0.21	3.06 ± 0.05	3.60 ± 0.27	0.25 ± 0.05	0.43 ± 0.02
Acclimation	20.4 ± 0.6	4.28 ± 0.16	3.06 ± 0.05	4.75 ± 0.22	0.13 ± 0.03	0.78 ± 0.04
Response	20.5 ± 0.9	4.34 ± 0.06	3.05 ± 0.03	5.23 ± 0.22	0.11 ± 0.01	0.79 ± 0.07

SAM = spatially adjacent monocultures; R and C and P = Ryegrass, clover and plantain

Cows grazing the SAM treatment were the only ones to show a difference in liveweight, with cows losing weight over the duration of the trial (initially 561 ± 21 kg, falling to 521 ± 16 kg), and they were also the only group to lose body condition score (-0.19 ± 0.11).

DISCUSSION

The range of NEFA and BHB levels found in all samples taken during the response period provided no indication of negative energy balance. All NEFA concentrations were less than 0.57 mg/dL (0.57 mmol/L), and all BHB concentrations were less than 10 mg/dL (0.96 mmol/L), which are the accepted thresholds that suggest sub-clinical metabolic stress (Ospina *et al.*, 2010).

Differences in BHB concentrations between samples may be a result of varying levels of butyrate production between the pasture mixtures. When butyrate crosses through the rumen wall it is metabolised to BHB and therefore pasture species that promote increased butyrate production can increase BHB levels in the blood (France and Dijkstra, 2005).

The BUN levels recorded for the SAM and clover and plantain treatments (Table 2) suggests they were eating a diet that was marginal in crude protein concentration. A blood urea nitrogen reading of between 14.8-16 mg/dL (5.28 - 5.71 mmol/L) indicates an adequate protein intake (Baker *et al.*, 1995, Roseler *et al.*, 1993). The slightly lower BUN concentration were obtained from cows in the ryegrass, clover and plantain mixture, and ryegrass treatments (Table 2), yet these were the treatments that produced milk with higher average milk protein percentages (Table 2). As the ryegrass treatment was one of the lower BUN concentrations, the other treatments were as good or better for crude protein concentration.

Although cows grazing the SAM treatment lost weight and body condition over the duration of the trial, neither NEFA nor BHB levels would suggest the cows were in negative energy balance. Even when analysing their NEFA and BHB levels during the acclimation phase there is no indication of negative energy balance, a condition that could explain the loss in both condition score and weight.

While this is a preliminary evaluation, repeated assessments of the treatments over different stages of lactation is required to compare the pasture treatments over different seasons and measure the individual pasture species ability to supply adequate nutrients to meet cow needs throughout a range of physiological states.

As there were neither milk yield differences, nor any indications of negative energy balance or nitrogen status when compared to perennial ryegrass, there should therefore be no negative consequences to mid lactation dairy cows grazing pastures that contain large proportions of plantain and white clover during mid-lactation.

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Identifying Risk Factors of Lameness in Pasture-Based Dairy Herds across NSW

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ABSTRACT

Lameness is a common health problem of dairy cows which results in significant economic losses to the dairy farmers. It causes discomfort to the cows and is a welfare issue in dairy farming. It has been associated with decreased milk production, impaired reproductive performance and increased risk of culling. Not much research has been done on lameness in Australia. This study aims to identify risk factors associated with lameness in dairy herds across N.S.W. It will also provide an estimate of prevalence of lameness in N.S.W. In this study prevalence of lameness in herds is evaluated using locomotion scoring. All milking cows are locomotion scored according to the locomotion scoring system developed by Cook et.al. (2004). Data related to herd management practices and herd environment are collected to assess their relationship to the level of lameness present on that farm. Due to the extensive number of variables and the lack of knowledge on prevalence of lameness in N.S.W the study aims to assess 75 dairy farms across N.S.W. So far 36 farms have been evaluated. Total of 10162 cows have been locomotion scored with the median of locomotion score of 2. Final results and analysis are pending completion of data collection. However prevalence of lameness across these farms (locomotion scores 3 and 4) ranges from 5 – 44.56%.

INTRODUCTION

Lameness has been classified as one of the three most costly diseases of dairy cattle. It is also considered the number one welfare concern in dairy cattle. It has been shown to impact welfare, reproduction, milk yield, mastitis and risk of culling. Overall incidence of lameness around the world has been reported to be 7 – 69% with a prevalence of 2 – 55%. The wide range of numbers between these reports indicates that lameness is a preventable condition. In order to prevent lameness a thorough knowledge of risk factors associated with lameness is essential.

Risk factors can be divided into three different categories; “Cow factors”, “Environmental factors” and “Nutrition factors”. Some individual cow risk factors include genetics, age, stage of lactation, parity, breed, body weight and condition, claw angle(Wells, Trent *et al.* 1993).

In a study on cows that were housed during winter it was shown that with age the rear leg becomes more sickled, affecting claw placement and locomotion, consequently the lowest prevalence of lameness occurs in first lactation cows and the prevalence increases with lactation number(Boelling and Pollott 1998). Hence, poorer locomotion is inevitable in dairy production systems focusing on a long-living high-producing cow. Bulls that transmit steeper foot angles and straighter legs when viewed from behind have fewer daughters with clinical lameness.

Lameness has been associated with high milk production at the beginning of lactation, and the incidence of lameness peaks in high-yielding cows three months after calving(Green, Hedges *et al.* 2002). Parturition and start of lactation cause non-inflammatory changes in connective tissue of the foot that impairs their resilience to external stresses associated with poor housing(Knott, Tarlton *et al.* 2007). This is known as the “Parturition Effect”.

The structure of the hoof epidermis is the link between nutrition and horn quality. Vitamins such as biotin and minerals in particular calcium are essential for activation of enzymes that are required for physiological keratinisation. Four to 6 months of daily supplementation of biotin reduces lameness and foot lesions at all stages of production by as much as 50%, although the level of reduction will vary between herds.(Green and Muelling 2005).

Environmental risk factors play a role by 1) influencing natural lying and standing behaviours, 2) promoting the onset of subacute ruminal acidosis during lactation which may lead to laminitis and claw horn lesions and 3) influencing rate of claw horn growth and wear on different walking surfaces(Cook, Nordlund *et al.* 2004).

Intensive farming and concrete surfaces have their role in increasing lameness among the herds. Excessive time spent standing on hard surfaces predisposes the hoof to claw horn lesions. Not many studies have been done on risk factors associated with lameness on pasture-based dairy systems. In New Zealand, Chesterton *et al.* demonstrated 24 statistically significant risk factors related to prevalence of lameness in 62 herds. Maintenance of the track and the patience of the farmer in bringing the cows in for milking were amongst the most influential risk factors related to the lameness level (Chesterton, Pfeiffer *et al.* 1989).

MATERIALS AND METHODS

In order to identify the prevalence of lameness on farms it was necessary to find a suitable locomotion scoring system. Several locomotion scoring systems were trialled on farm and the system developed by Nigel Cook (2004) was chosen. The locomotion scoring system needed to be simple, quick, and also be able to be done as the cow was walking by. By locomotion scoring the milking herd an estimate of prevalence of lameness was attained.

A literature review was done to evaluate recent research on risk factors for lameness in other parts of the world. An assessment sheet was developed to organize and facilitate on-farm assessment. It consists of three parts; the “Farmer Sheet” used to interview the farmer about management practices of the dairy, the “Investigator Sheet” used to record comprehensive data collected and measured on farm, and the “Locomotion Scoring Sheet”.

Every farm is visited once and the duration of the visit depends on the number of cows being milked, the length of time milking takes and the time to assess the farm environment and measure the tracks. Areas that are assessed include the milking yard, the milking shed, the feed-pad (if used on the farm), the foot bath (if used on the farm) and the “Main” track used by cows on a daily basis. Important aspects likely to contribute to lameness are measured and recorded. These include the area available per cow in the holding yard, the gradient of the holding yard, and the area available per cow on the feed pad. The total length of the main track is measured using a (what is that thing called!!) and the average width and gradient is determined every 50 meters. At the time of milking, cattle handling and cattle behaviour are assessed and monitored along the track, in the milking yard and during milking. Each cow is then locomotion scored as she leaves the dairy. Locomotion scoring is done after milking and on a flat surface (preferably also hard like concrete) in order to get the most accurate results.

RESULTS AND DISCUSSION

So far preliminary data has been collected from 36 dairy farms across NSW. Almost 10162 dairy cows have been locomotion scored with the median score of 2.

The farms will be categorised into two groups of high and low lameness herds using locomotion scorings, and potential risk factors in high lameness herds determined using ordinal regression. The regression analysis will also allow the risk factors to be categorised according to their contribution to lameness in these herds. This will help us in guiding farmers on lameness prevention by tackling the risk factors that potentially have more effect on lameness in their herd.

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Polarising the Future Potential of Poll in the Australian Dairy Industry

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ABSTRACT

With animal welfare concerns having shown to significantly impact other Australian livestock industries the importance of protecting both the image and economic future of the Australia dairy industry is of critical concern to all involved. An area of the industry which is vulnerable to this criticism is dehorning/ disbudding and globally this has seen, in recent years, the importance of poll increase significantly. This threat exists not only in the potential damage to the Industry's image, but also damage as a result of potential losses in genetic gain due the historical dominance of the horned allele within elite sires of the industry. The Mendelian mode of inheritance of poll offers a significant opportunity to the 1.6 million dairy cattle in Australia, of which it is unknown the proportion that are phenotypically expressing poll. The lack of any correlation to major production traits and poll allele highlights the potential breeding options available to the industry. With the use of modeling techniques it has been shown that breeders are able to maintain poll within herd with the use of only one generation of poll breeding. After which point they can continue to use sires with horned alleles and maintain a poll population. The issues around dehorning/ disbudding are further compounded by the low awareness of the industry to poll and poll breeding strategies and emphasizes the need to promote and further evaluate poll and associated traits (e.g. scurs).

INTRODUCTION

The historical dominance of horned cattle within elite sires of the global dairy population has created a genetic phenomenon expressed in the prevalence of the recessive phenotype, horns, within the dairy population. This feature of the industry means that the process of dehorning/ disbudding has become essential to husbandry requirements of the cow in many countries. This could be damaging to the industry because it exposes the dairy industry to animal welfare concerns held by the public.

Horn removal is generally achieved using heat cauterisation, often without the use of anaesthetic and is therefore considered an animal welfare issue. This process of dehorning/disbudding is performed on an unknown proportion of the 1.6 million dairy cattle in Australia. The solution to removing the vulnerability of the industry is the targeted breeding of hornless or poll cattle.

The lack of any known correlation between major production traits and the poll allele highlights the potential breeding options available to the industry and could be enhanced further through genomic testing. Selecting for poll is currently difficult because of low numbers of available sires, many having inferior genetic merit, the low economic cost of dehorning/disbudding and the lack of understanding around the genetic and phenotypic aspects of the trait.

Difficulty in identifying both the poll phenotype and the benefits poll offers a breeding program, is probably because of a lack of industry education around the phenotypes. Poll phenotypes are also sometimes confused with the scurred phenotype (Figure 1.1); however these conditions are genetically distinct.

Figures 1.1: Displays phenotypic expressions of the alleles associated with poll (From left to right- polled, scurs and horned)

The genomic region responsible for genetically controlling polled has already been characterized by Seichter *et al.* (2012) and later Medugorac *et al.* (2012).They suggest that a haplotype exists that is perfectly associated with polledness in Holsteins at 1.668–2.049 Mb on chromosome 1 (on build UMD 3.1). If this single-nucleotide polymorphism (SNP) can be identified and incorporated into commercialized genetic marker panels (such as parentage verification chips), then this would be a major step forward in selecting for poll cattle. However, genetic marker based tests are already available, which are currently too costly for commercial producers to incorporate into their management decisions.

However, breeding companies regularly use these tests and there are already polled bulls available in Australia that can be used in farmers' breeding programmes.

AIM

Using a horned population of females, devise an easy to implement breeding program to use heterozygous (Ph) males of inferior genetic merit to generate a polled herd.

METHOD

Development of poll modelling program

The poll inheritance model was developed in Microsoft Excel®. Features of the model included using inheritance principles of the Mendelian punnett square applied over each generation and repeating this procedure over successive generations.

It was assumed that an individual requires 3 years to replace an existing animal within the modelling program, that the sex ratio was 1:1 (male: female) and a mortality rate from birth to entering the herd was 0.78. The program is capable of using different replacement rates. The herd's founding population was entirely horned (hh).

In the first year the homozygous (hh) population was bred to heterozygous (Ph) sires. Heterozygous (Ph) and homozygous (hh) individuals were retained over successive years of the program with those individuals retained in the population with a heterozygous (Ph) genotype being bred to homozygous (hh) sires (Figure 2.1).

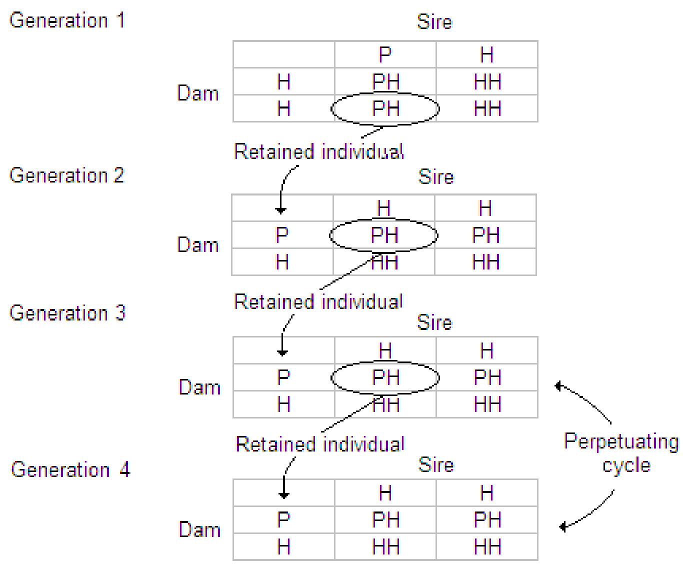

Figure 2.1: Punnett square analysis of the inclusion of poll over successive generations with the single use of heterozygous sire (Ph)

Simple Mendelian inheritance was used to determine that if simple criteria are followed; retain only poll offspring, then poll can be maintained indefinitely within a population through the single use of a poll animal (genotype Ph or PP) in a breeding line without the need to use any further poll sires.

Measure of genetic merit

Throughout the paper the genetic merit of an individual will be related to the individual's Australian profit ranking (APR). The APR represents a breeding index taking into account the traits relevant to profitability in the Australian dairy farming system and rating how much more/less profitable an individual is compared to the average for the breed.

Parameters of genetic merit

An APR of 150 was assumed for every individual in the starting population. Heterozygous (Ph) sires were assumed to have an inferior APR of 100. Homozygous (hh) sires had an APR of 150.

The progeny from a mating within the program had an APR determined with the following equation;

(APR of sire + APR of dam) / 2

RESULTS

Modeling of the rate of inclusion

Assuming a 25% replacement rate and by following the rules set up in the computer simulation, the proportion of the herd that would be heterozygous (Ph) after 5 years of selection would be 38.8% and by 8 years of selection this would become 94.2% (Figure 3.1).

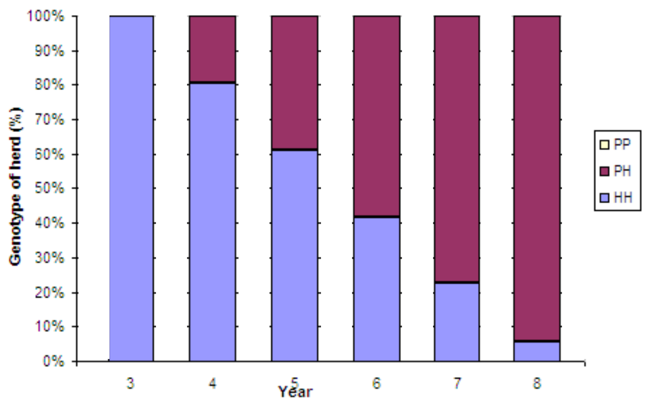

Figure 3.1 : Inclusion of poll over successive years in a breeding program based on a replacement rate of 25%

Implication of inclusion of lower quality genetic

The impact on genetic gain is shown in figure 3.2. As it was assumed that polled bulls had lower genetic merit (APR = 100) there was an initial reduction to average APR of 125 in generation 3, when poll was inserted. However, this was recovered by the 6th generation because of the ability to use homozygous (hh) sires (APR = 150).

Figure 3.3 shows the herd level implication on genetic gain of the use of lower genet merit poll sires (APR = 100). APR falls as a function of replacement rate to its lowest APR of 133.07 at year 7. The highest proportion (94.2%) of heterozygous individuals in the herd is achieved in the 8th year, after which the proportion of poll animals remains the same despite the APR increasing, due to the increased use of homozygous (hh) sires (APR =150). At a herd level the inclusion of poll required 16 years to be mitigated.

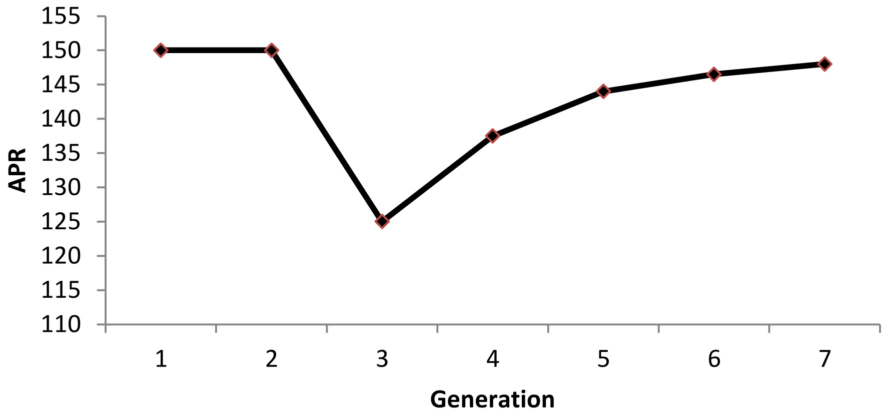

Figure 3.2: Inclusion of poll, associated with lower merit genetics *(APR-100)* over successive generations

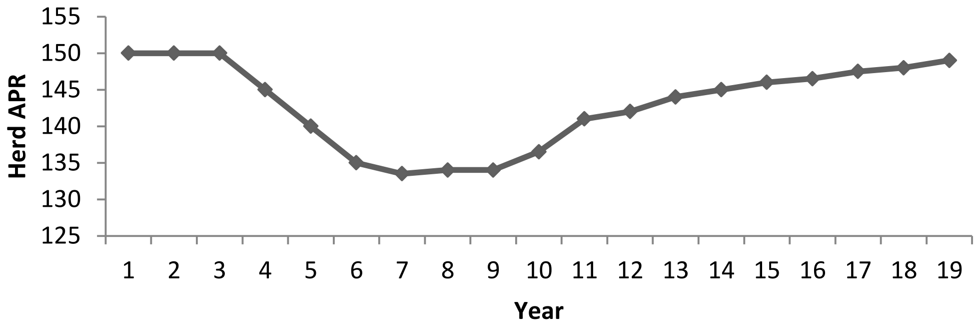

Figure 3.3: Inclusion of poll, associated with lower merit genetics (APR = 100) over successive years in a breeding program based on a replacement rate of 25%

DISCUSSION

The findings of this study indicate it is possible for producers to naturally integrate poll into a pre-existing homozygous (hh) herd with the use of heterozygous (Ph) sires in a single generation of the herd's breeding plan. As polled is a trait that follows simple Mendelian inheritance it was possible to retain the dominant phenotype (polled) within the breeding lines despite the use of homozygous (hh) sires after the initial insertion of the poll allele. This relied on the assumption that only poll offspring were retained as replacements for the population.

The implications of the findings are important to the Australian dairy industry, as it has been demonstrated that achieving a poll status herd is relatively simple to achieve. Although the results are not unexpected the implication and the education of industry around the practical implementation of the concepts have the potential to dramatically change the industry. The long term maintenance of poll in the Australian dairy industry relies on minimal criteria around sire selection decisions due to the strong correlation to farm performance. The requirement for a single use of a sire to insert the gene means that the breeding options of the producer are open for successive generations where breeding focus can change as long as only poll/scurred offspring are retained.

As previously mentioned the inclusion of poll into the Australian dairy industry requires a shift initially away from the conventional sires. This shift could lead to a reduction in genetic gain for profitability (as measured by APR) and thus the importance of understanding the loss is critical for industry acceptance. The ability to model the impact both at a herd and generation level showed that the impact of the inclusion is significant.

One of the purposes of the model was to illustrate the impact of inclusion of the poll allele when it is associated with lower genetic merit sires (APR = 100). The findings showed that the impact of the inclusion was completely recovered after the 6th generation in a breeding line. In terms of a breeding population the impact required 16 years to be mitigated and saw the herd average drop to an APR of 133.07. It is important consideration that as poll becomes of increased importance the quality of polled bulls available will increase and the use of them may incur no loss in genetic gain (as measure by APR).

Effectiveness of poll model

The model identified an expected rate of inclusion of poll into the population and the significance of the replacement rate, as expected, is evident. The model however responds in a very basic way to the inclusion of low genetic merit sires.

The repeated use of heterozygous (Ph) to homozygous (hh) matings were used as they illustrate the least efficient way of successfully achieving a poll herd. This was apparent in the model which failed in every year of the breeding program to produce an entire year's worth of replacements that were heterozygous (Ph). As a result of utilising this mating strategy the program was capable of modelling the worst case scenario for losses in genetic gain associated with poll breeding, due to the prolonged nature of the traits insertion. This worst case scenario is of most value to the Australian dairy industry due to the current lack of any genetic testing option to identify homozygous (PP) individuals and the dominance of heterozygous (Ph) bulls in the poll sire market.

Potential implications to industry

The paper has shown that the implications of inserting one generation of poll genetics into the herd can have massive ramifications on the need to dehorn/disbud. The dominant inheritance of poll removes the necessity to dehorn animals carrying a single copy of the allele and has the potential to prevent some of the animal welfare concerns of the public.

So far this paper has focused on natural methods of breeding poll, focussing on minimum requires for inclusion, and ignoring the homozygous (PP) individuals. The ability to identify not only homozygous (PP) bulls but also homozygous (PP) cows would benefit the industry greatly, however as this paper has shown is not essential for poll breeding. The identification of a SNP or set of SNP is a major step towards the confident adoption of poll within industry however the true benefit will be gained from the commercialisation of the SNP. A feature which would enable producers to target homozygous (PP) individuals as replacements from heterozygous (Ph) matings, due to the benefit they offer in 100% of their offspring being polled/scurred.

CONCLUSION

A breeding program to select for poll individuals that can be implemented by producers was devised. The findings showed it was possible for producers to maintain poll within their herd with the use of only one generation of poll breeding. After which point they can continue to use sires with horned alleles and maintain a poll population. It was shown that 6 generations are required at a generation level and 16 years at a herd level to mitigate the impact of the insertion of low merit genetics assumed to be associated with polled sires.

Can Digital Infrared Thermography Help with Prediction of Ovulation in a Pasture-Based Dairy System?

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ABSTRACT

This study was designed to assess the potential of digital infrared thermography as a predictor of ovulation in dairy cows. Twenty cows were synchronized using controlled internal drug release (CIDR) and prostaglandinF2α. Vulva and muzzle temperatures were measured every 12 h (hour) from CIDR insertion to 32 h post PGF2α injection and then every 4 h until ovulation occurred. Thermal images obtained with a FLIR T620 series infrared camera were analysed using ThermaCAM Researcher Professional 2.9 software. The relationships between vulva and muzzle temperature with time of ovulation were analysed by linear mixed model using Genstat version 14. The mean time of onset of standing oestrus was 66 ± 17 h after PGF2α injection. Significant ($P < 0.05$) changes of vulva and muzzle temperatures were observed 48 h prior to ovulation. Vulva and muzzle temperatures were significantly ($P < 0.01$) associated with time of day and showed diurnal rhythm over the experimental period. The highest and lowest vulva and muzzle temperatures were recorded around midday (10:00 and 14:00) and in the early morning (around 06:00) respectively. Further biometrical approaches are required to confirm the potential use of this technology by comparing with hormonal level.

INTRODUCTION

Infrared thermography (IRT) is a non-invasive, non-contact and safe technique of thermal visualization through which temperatures are monitored and recorded. IRT has been used in medical and veterinary science. In these fields, applications have included oncology, allergic diseases, plastic surgery, rheumatology, reproductive problems (Scolari *et al* 2011), early detection of foot pathologies (Alsaaod *et al* 2012) and mastitis (Colak *et al* 2008) in dairy cows.

It has been observed that IRT can be used to detect changes in vulva temperatures between oestrus and di-oestrus sows (Scolari *et al* 2011; Sykes *et al* 2012). Jones *et al.* (2005) evaluated this technology in dairy cows and was able to discriminate first oestrous from di-oestrus after oestrus synchrony but not in subsequent cycles. However, no information regarding the housing system and methods for differentiating oestrus from di-oestrus groups were reported in that study. To the best of our knowledge there are no studies that have investigated the potential use of IRT to detect oestrus and ovulation in dairy cows. Therefore, the aim of this study was to explore the potential use of IRT in detection of vulva or muzzle temperature changes with time to ovulation.

MATERIALS AND METHODOLOGY

Twenty healthy, lactating, cycling Holstein Friesian dairy cows averaging 65 ± 5 DIM and 27 ± 6 kg of milk production (mean ± SD) were enrolled in the study during October and November 2012. Cows were fed a pasture-based diet (pasture plus concentrate at milking). Prior to the study commencing, cows were subjected to ultrasound scanning to confirm the presence of growing follicle(s) and absence of any corpus luteum and abnormal structures (cysts). Oestrus was synchronized by inserting a controlled internal drug release (CIDR) (Eazi-Breed®, Pfizer Animal Health Limited, West Ryde, NSW) into the vagina for 8 days. After 8 days, CIDR's were removed and 2ml (500µg) $PGF_{2\alpha}$ synthetic prostaglandin analogue, cloprostenol sodium (Estrumate®, Schering-Plough Animal Health Limited, Baulkham Hills, NSW) was administered to each cow. From 36 h after $PGF_{2\alpha}$ injection cows were monitored at 4 h intervals for any behavioural signs of oestrus until ovulation occurred as determined by transrectal ultrasound scanning (Ibex Pro portable ultrasound, E.I. Medical Imaging, USA). Onset of oestrus was defined as when the cows were observed to be mounted by one or more herd mates (standing oestrus). Vulva and muzzle skin IRT was performed by means of an infrared camera (FLIR, 620 series, FLIR Systems Co. Ltd.) from a fixed distance of 1 meter from the animal. Before each IRT scanning session, the emissivity value was set to 0.98 and thermograph resolution was calibrated to ambient temperature and humidity as per manufacturer's recommendations. IRT was performed twice daily at 6.00 h and 14.00 h between 24 h before and 32 h after $PGF_{2\alpha}$ injection before onset of oestrus to establish baseline temperatures. Thirty-six hours after the $PGF_{2\alpha}$ injection, IRT was performed at 4 h intervals until ovulation occurred. Vulva and muzzle temperatures were measured to correlate the temperature at two different areas of body. Images were analysed by ThermaCAM Researcher Professional 2.9 software. The software allowed the user to obtain the temperature of a defined area on the image and calculated the minimum, maximum, and average temperatures and standard deviation for each measuring field. A free hand drawn geometrical polygonal shape covering the entire vulva area was used for calculation of temperature of vulva images while the muzzle temperature was determined in a square area between the two nostrils. At each IRT scanning session, vaginal temperature was recorded with a digital thermometer and ovarian activity was also monitored via transrectal ultrasound scanning every 8 h between 48 to 68 h of $PGF_{2\alpha}$ injection and at 4 h intervals thereafter until ovulation occurred. At each scanning, the number and the size of any ovarian follicles were recorded. Time of ovulation was defined as the first scanning session at which the dominant follicle had disappeared minus 2 h. Ambient temperature and humidity were recorded at each time of IRT scanning from a solar weather station (Oregon Scientific International Ltd., Los Angeles, USA). Temperature humidity index (THI) was calculated for each IRT scanning session using the equation reported by Kendall *et al.* (2008): $THI = [(1.8 \times T + 32) - \{(0.55 - 0.0055 \times RH) \times (1.8 \times T - 26)\}]$.

Data gathered in this study was analysed by linear mixed model using GenStat 14th Edition (VSN International, Hertfordshire, UK). All the variables were initially assessed using descriptive statistics and variables that had skewed distributions were logarithm transformed before conducting the univariable analyses. Changes in vulva and muzzle temperatures were analysed in relation to time to ovulation and time of day by linear mixed models considering THI as a covariate and cow identification as random factor. This study was approved by the Animals

Ethics Committee (The University of Sydney, NSW, Australia, approval number: N00/9-2012/1/5829).

RESULTS

Of the 20 cows enrolled in this study, 12 ovulated, 7 did not ovulate and 1 cow developed cystic ovaries. Data from anovulated and cystic cows were not included in these analyses. The interval between $PGF_{2\alpha}$ injection and the onset of standing oestrus was 66 ± 17h whilst the interval between $PGF_{2\alpha}$ injection and ovulation was 89 ± 21 h. The mean interval between onset of standing oestrus and ovulation was 24 ± 15 h.

In the present study, average and maximum temperature of both muzzle and vulva differed significantly (P < 0.05) in relation to time to ovulation (Figure 1). Maximum vulva and muzzle temperatures were used for the representation of results due to imparting lower P value for linear mixed models compared to the average temperature. Whilst the highest vulva and vaginal temperatures were observed 24 h before ovulation only the vulva temperature was significantly higher than other recorded temperatures.

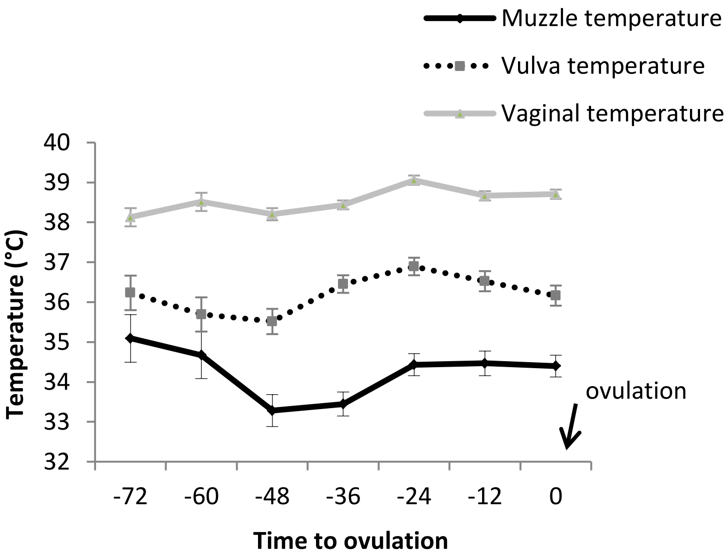

Figure 1: Maximum muzzle, vulva and vaginal temperature in relation to time to ovulation. Temperatures at 4 hour interval were pooled for every 12 hour

On the other hand, the lowest vulva and vaginal temperatures were observed 48 and 72 h before ovulation respectively. The maximum and minimum muzzle temperatures were noted during 72 and 48 h before ovulation. The muzzle, vulva and vaginal temperatures recorded 48 h prior to ovulation were significantly ($P < 0.05$) lower than those temperatures recorded at ovulation. Vulva and vaginal temperature increased 24 h before ovulation and then decreased at the time of ovulation ($P < 0.05$). Muzzle temperature was relatively steady during the last 24 h before ovulation (Figure 1).

As expected, vulva and muzzle temperatures changed significantly ($P < 0.05$) during the time of day (Figure 2). Those temperatures were highest respectively during afternoon and late morning while the lowest vulva and muzzle temperatures were observed in the morning (around 06:00).

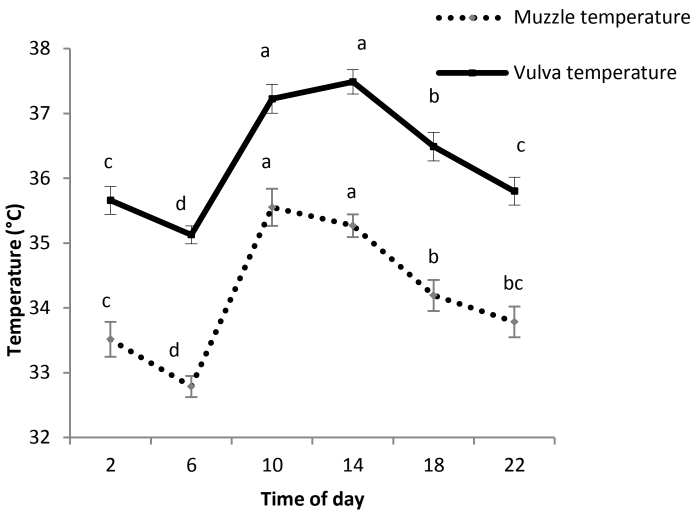

Figure 2: Vulva and muzzle maximum temperatures at different time of day

DISCUSSION

In the present study, the duration between standing oestrus and ovulation was 24 h. This duration was slightly shorter than that was reported by Roelofs *et al.* (2004) which was 28 h.

Significant decrease of muzzle and vulva temperature 48 h prior to ovulation followed by a sharp rise of those temperatures 24 h before ovulation was noted in the current study. Using IRT Scolari *et al* (2011) observed the most marked decrease in vulva temperature from 36 and 24 h prior to ovulation in sows. Ovulation occurs approximately 30 h after the first display of standing oestrus in cows. In the present study, the sharp increase of muzzle, vulva and vaginal temperature from 48 h to 24 h before ovulation is likely to coincide with the timing of oestrus. The core body temperature rises 0.3° to 1.1°C (Kyle *et al* 1998) or 0.9 to 1.3°C (Piccione *et al* 2003), or maximum 0.5°C (Suthar *et al* 2011) at oestrus and stays elevated for 3.8 to 9.2 hours (Kyle *et al* 1998; Redden *et al* 1993). Moreover, there is a pre-oestrus decrease in body temperature 1-2 days prior to the oestrual temperature increase (Kyle *et al* 1998). Such a cyclic temperature variation might be related to blood progesterone concentration (Wrenn *et al* 1958). Further approaches to determine the correlation of vulva and muzzle temperature with progesterone profiles would be required. In the present study, the significant increase in vulva temperature in relation to time of ovulation is encouraging enough to further evaluate the potential application of IRT scanning as an aid in predicting time of ovulation. IRT scanning of other body areas for example eyes might be conducted as it has been reported to be an indicator of body temperature (Johnson *et al* 2011).

The short duration of the core body temperature rise at oestrus may create challenges with detection if IRT technology is used to capture temperature changes at milking sessions for dairy cows. The short sampling interval employed in the current study suggests that the technology may be capable of detecting the change but taking this to a practical on-farm application may prove challenging.

Diurnal variations of vulva and muzzle temperatures are consistent with other studies (Nabenishi *et al* 2011). Such distinction in temperature rhythm has been reported to be more marked during hot periods compared with that of cool periods (Nabenishi *et al* 2011). The highest ambient temperature during afternoon may attribute to the highest vulva temperature observed at that time of day. The heat dissipation mechanisms of the muzzle might explain the decreased muzzle temperature during the afternoon compared with that recorded during late morning.

CONCLUSION

Infrared cameras might have potential for prediction of ovulation in dairy cows. Biometrical approaches are required to determine the sensitivity and specificity of IRT. Moreover, the correlation of fluctuation of temperature with hormonal profiles also needs to be evaluated to determine the timing of temperature changes in relation to defined oestrus.

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