THE DAIRY RESEARCH FOUNDATION'S

2014 SYMPOSIUM

JUNE 19-20
POKOLBIN, HUNTER VALLEY NSW

GROWTH THROUGH SCIENCE & INNOVATION

FACULTY OF VETERINARY SCIENCE

THE UNIVERSITY OF SYDNEY

DAIRY RESEARCH FOUNDATION

CURRENT TOPICS IN DAIRY PRODUCTION

Volume 19

June 19 and 20, 2014

For further information please visit **www.dairyaustralia.com.au**


Dairy Australia
Your Levy at Work
Dairy Australia
Sharing knowledge and learning for the future.
Dairy Australia is proud to support a wide range of events, conferences and information seminars such as the Dairy Research Foundation Symposium.
This is just one of the many ways you'll see your levy at work.

DAIRY RESEARCH FOUNDATION

CURRENT TOPICS IN DAIRY PRODUCTION

VOLUME 19

2014

Compiled by Michelle Heward

Edited by Kendra Kerrisk, Yani Garcia, Sherry Catt and Michelle Heward

CONTENTS

WELCOME TO THE DAIRY RESEARCH FOUNDATION 2014 SYMPOSIUM 4

DAIRY RESEARCH FOUNDATION 2014 SYMPOSIUM ORGANISING COMMITTEE 5

THE EMERGING DAIRY SCIENTISTS' PROGRAM 5

SYMPOSIUM SPONSORS 6

DAIRY BUSINESS RESILIENCE AND GROWTH IN A VOLATILE ENVIRONMENT 7

John Mulvany

LOOKING AT THE NSW DAIRY INDUSTRY THROUGH THE DAIRY FARM MONITOR PROJECT 17

Kerry Kempton

DAIRY FARMER Z 25

Cameron Clark

REALIZING THE HOLY GRAIL OF SEX SELECTION IN THE BOVINE 31

Mike Holland

TAKING TECHNOLOGY TO NEW HEIGHTS 39

Mark Billing

SHOULD ANYONE BUILD A NEW DAIRY WITH A ROBOT? 42

Kendra Kerrisk

ROBOTS CONVERT RUN OFF BLOCK INTO A PROFITABLE DAIRY 48

Marcus Crowden

CAMELOT 'WHERE MAGIC HAPPENS' 51

Frances Beeston

THE FUTURE OF RURAL EDUCATION 55

Cameron Archer

EFFECT OF RANKING FOR RESIDUAL FEED INTAKE ON RUMINAL METHANE EMISSIONS FROM HEIFERS 60

Ruairi McDonnell

INSIDE THE MIND OF THE COW: UNDERSTANDING VOLUNTARY COW TRAFFIC BEHAVIOUR IN A PASTURE-BASED AUTOMATIC MILKING SYSTEM 66

Tori Scott

THE IMPACT OF MILKING ORDER ON THE QUALITY AND QUANTITY OF PASTURE ACCESSED 73

Beth Scott

DETERMINING THE SAFETY AND LIKELY WITHHOLDING PERIOD OF A NEW INTRAMAMMARY MASTITIS THERAPY 78

Patricia Eats

ANTHELMINTIC RESISTANCE ON MACALISTER IRRIGATION DISTRICT DAIRY FARMS 85

Stephanie Bullen

RUMINATION PATTERNS AND LOCOMOTION ACTIVITY IN A DAIRY COW DIAGNOSED WITH LEFT DISPLACED ABOMASUM (LDA): A CASE REPORT 91

Saranika Talukder

INVESTIGATION INTO THE CHALLENGES ASSOCIATED WITH REPRODUCTIVE MANAGEMENT ON COMMERCIAL DAIRY FARMS UTILIZING AUTOMATIC MILKING SYSTEMS 96

Derek Keeper

ANTI-MÜLLERIAN HORMONE: RELATIONSHIP WITH CALVING TO MATING AND CALVING TO CONCEPTION INTERVAL 100

Sarah Teirney

IMPACT OF AUTOMATIC MILKING SYSTEMS (AMS) ON LABOUR AND LIFESTYLE ON COMMERCIAL FARMS IN AUSTRALIA 105

Juan Molfino

WELCOME TO THE DAIRY RESEARCH FOUNDATION 2014 SYMPOSIUM

It is with pleasure that we take the much loved Dairy Research Foundation Symposium to the Hunter Valley. We have welcomed the opportunity to take dairy science on the road under our theme of growth through science and innovation. And, the Hunter Valley provides the perfect canvas to do exactly that.

We are proud that the Symposium has become a hub of industry meetings and we welcome the collaboration of Dairy NSW Regional Development Program and Dairy Connect both of whom are staging meetings over the duration of the event. This is very much now the pinnacle dairy event for NSW.

We have amassed a wonderful team of speakers, spearheaded by Dr John Penno – acclaimed dairy scientist and now head of one of the most successful processing companies, the NZ-based Synlait. John is a dynamo speaker and he is then joined by his namesake in Victorian dairy business consultant John Mulvany – who comes to NSW with a reputation for innovative business insight but a rare capacity to extract the most fascinating level of detail out of farm businesses.

As the Foundation shares its headquarters with FutureDairy, the project charged with leading the automated milking systems research in Australia, it comes as no surprise to find the Symposium provides the opportunity for delegates to meet three great young people all of whom have recently invested in robotic technology.

And as delegates have come to expect, this program would be incomplete without someone on it to make us think completely differently about ourselves and our industry. This year we have turned to advertising guru, former Dubbo boy, Craig Davis to do that. Craig shot to fame when he spoke at the Australian Farm Institute conference and accused Australia of having 'supermodel syndrome' when it came to positioning itself overseas. Craig has a fascinating portfolio of clients with whom he has worked to change attitude and create demand. His philosophies will undoubtedly have great relevance to the opportunities for creating demand for NSW dairy products.

On Day 2 delegates head to Singleton to meet John & Allison and Daniel & Sarah Redgrove to get an insight into one of the most innovative dairy businesses in the Hunter. Their property is being used as the canvas for the popular Emerging Scientists program - where delegates will get to meet some of the country's most promising future dairy scientists.

We hope you enjoy our 2014 program in the Hunter Valley.

Assoc. Professor Kendra Kerrisk
Programming Committee Chair,
Dairy Research Foundation Symposium 2014

DAIRY RESEARCH FOUNDATION 2014 SYMPOSIUM ORGANISING COMMITTEE

Associate Professor Yani Garcia, University of Sydney	Mr Bill Inglis, Dairy Research Foundation
Associate Professor Kendra Kerrisk, University of Sydney	Dr Cameron Clark, University of Sydney
Ms Kerry Kempton, NSW Department of Primary Industries	Dr Alison Gunn, University of Sydney
Ms Lynne Strong, Clover Hill Dairies	Dr Neil Moss, SBSCibus
Ms Sherry Catt, University of Sydney	Mr Michael Perich, Dairy NSW
Ms Michelle Heward, University of Sydney	Dr Nicolas Lyons, University of Sydney

THE EMERGING DAIRY SCIENTISTS' PROGRAM

The DRF is pleased to showcase the talents of 9 emerging dairy scientists at the 2014 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 scientists.

DAIRY RESEARCH FOUNDATION 2014
SYMPOSIUM SPONSORS

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

Please Note: Sponsor information is correct at the time of printing

PLATINUM

GOLD

SILVER

BRONZE

DAIRY BUSINESS RESILIENCE AND GROWTH IN A VOLATILE ENVIRONMENT

John Mulvany

ONFARM Consulting
Leongatha Victoria 3953

Introduction

My first conference presentation was at Nowra in May 1996. For various reasons, I was almost ejected from NSW and probably deserved it as a young, arrogant Victorian. It is appropriate then, that in the twilight of my career I return to NSW, but with a significantly different attitude to the Dairy Industry and production systems.

In particular, over the past six years, with the GFC and work with farmers in Western Australia, Tasmania, NSW and most areas in Victoria, I have had some long held beliefs challenged, and definitely have had to change the way I view dairy businesses.

Conversations at the tables of most dairy farmers now focus on the same areas of volatility in all regions: milk price, season, supplement price, the cost and availability of labour, and the competition for scarce land resources at a realistic price. I believe that now more than ever before, there is an 'eastern states' dairy industry and that the traditional state boundaries and a 'them versus us' mentality is disappearing.

This paper will consider, briefly, the external factors impacting on dairy businesses, but focus mainly on the factors within individual businesses that provide resilience and allow growth in a volatile external environment

Is what I cover new? Probably not

In 1830, Thomas Macaulay said:

'…on what principle is it that when we see nothing but improvement behind us we are to expect nothing but deterioration before us….'

In the past 20 years, we have made very significant gains in applied knowledge on dairy farms but at the same time have introduced excessive complexity. There is no shortage of information or advice on what to do. The absolute skill of any dairy farmer is selecting what not to do and not allowing an area's culture to drive decisions.

The Externals That Impact a Dairy Business: Milk Price, Season, and Supplements

Milk Price

The national 'hunt' for milk in recent years has meant that the previous very clear line between Domestic and Exporting Processors is now quite blurred. A change to payment systems by the major Victorian Processors, in particular Murray Goulburn, and a subsequent movement into the NSW market, has provided opportunity, but, as always, with opportunity there is risk.

Fixed volumes of deliverable milk (i.e. quota) but low and volatile surplus milk price do not encourage farm growth or allow opportunities to be taken when they arise. The ability to produce as much as you want and receive virtually the same price for all the milk means that efficient farmers can grasp opportunities to grow and profit from marginal milk.

However, the unlimited production world also has price volatility in all the milk and this is likely to be more volatile than it has been previously in NSW. By introducing the Domestic payment system (now called flat milk system, even though it's not) it has essentially put a base price on the value of what would have been previously termed market milk.

The following table presents the price paid for the same milk flow supplied from a NSW farm and a Victorian Murray Goulburn farm as estimated in May 2014 (Source MG Income estimates).

160,047 kg milk solids 2.227 million litres	
NSW	**VICTORIA**
$7.31/kg MS (52.6 c/L)	**$6.53/ kg MS (47 c/L)**
Difference = $0.78 /kg MS (5.6 c/L)	

It's interesting to note that:

- The cost of a 40,000 litre tanker from Cobram to Sydney would convert to 6.1 cents per litre (c/L) or $0.84 per kg milk solids (kg MS).
- Since its introduction in 2010/2011, the Domestic price has averaged $5.82/kg MS (42 c/L) and this includes the current record year.
- Applying the cartage differential, it means that if I was asked what base price a farm in NSW would have to be able to cope with, the answer would be $6.62 per kg MS (48 c/L).
- This is <u>not</u> the required milk price for growth, which I have estimated as $6.00/kg MS (43.4 c/L) in Victoria, while in NSW it's closer to $7.00/kg MS (52 c/L).
- I note from the NSW Dairy Farm Monitor figures that the average milk price paid in 2011/2012 in NSW was $6.88 per kg MS (49.5 cents/L); in 2012/2013 it was $6.43 (46.2 c/L).

The bottom line is that the Australian Dairy industry needs to be able to be profitable at $6.00 per kg MS (43.4 c/L), almost irrespective of where you are situated. In addition, there are no signs that milk prices will not be volatile in the future.

Supplement prices

The price of supplements, in particular processed concentrate, appears to vary directly in line with milk price. Recent prices obtained from NSW for delivery to the South and North Coast are a major concern. A reasonable quality pellet at $450 per tonne requires a milk price of $7.50/kg MS (54 c/L) to create a safe margin – a milk price/concentrate price ratio of 1.2, and I'd prefer 1.5! The price differential between grain and pellets seems to be high and it's difficult to explain more than $60 - 70 per tonne.

The same can be said for fodder prices of $450 per tonne for high quality Lucerne hay. (Sources Phil Pittolo and Neil Moss NSW)

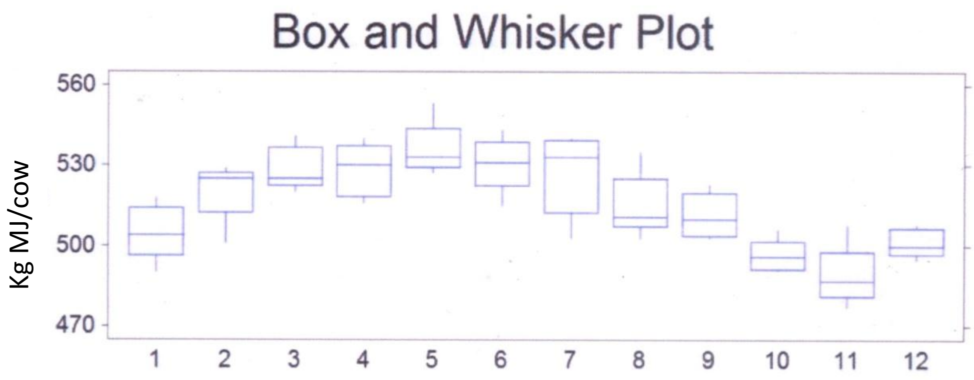
Supplement prices will continue to be volatile and, in reality, the NSW position is similar to other regions, in that the higher supplement prices are offset by higher milk prices so the ratio stays similar, placing profit pressure on marginal milk.

Seasonal Variation

A recent study initiated by Fonterra Australia investigated the 'within year' feed costs variation on dryland and irrigated dairy farms, with a range of production and calving patterns.

Across this broad range of farms, it would appear that there are 3 - 4 months in most regions when there is reliable pasture growth (spring!); outside that period there is definitely significantly higher cost (often double) and in dry land areas low reliability of pasture growth.

The following graph (provided by Neil Moss) indicates production per cow as related to calving date. If I were a cow I really would prefer not to calve from November onwards in Bega! I will struggle for direct harvest feed Sept – Oct.



Month of calving – 60 cases

Issues such as late autumn breaks, perennials that struggle to survive, availability or cost of irrigation water, all indicate that the seasonal variations are probably greater than those experienced previously, particularly in low rainfall areas - irrespective of state borders.

Since there is less external certainty than previously, the challenge is to position a dairy business to exploit the times with good external conditions and be able to be resilient in the 'shockers'!

Evidence of a 'National Dairy Industry'

If there is doubt about the merging of the state industries consider the following.

% Imported Feed 2012/2013				
Victoria			New South Wales	
North	Gipps	West	North	South
47%	38%	42%	41%	45%

Victoria used to be 20% imported feed.

In terms of frequency of calving and calving patterns, there has been a dramatic increase in split calving herds in our client group, from 10% in 1998 to 52% in 2012/2013 (higher in the general population). I would estimate that the proportion of herds that completely dry off and the farm ceases sending milk for a period would now be less than 3%.

The historic concept of a 'seasonal herd' needs complete re-defining!

The Concept of Seasonality Re-Defined

In the late 80's and 90's, the term referred to herds that predominantly calve in late winter and spring. It was also established that, in those years, seasonal herds had lower costs than other herds, especially split calving herds. Ellinbank Research Centre conducted studies in the late 1980's that confirmed that seasonal, single calving herds had lower costs than autumn calving herds. This belief has continued, but is now an unsubstantiated assumption in the dairy industry and the term seasonal needs to be re-defined:

Seasonal milk production is calving and producing milk to match the pasture/forage production curve on a farm, to enable maximum direct harvest, low cost feed intakes in cows.

It is also important to remember that 'seasonal' production is not just about pasture; it refers to the ability of farmers to produce additional platforms of feed, such as 'autumn start' crops in northern Victoria, deep rooted crops such as chicory in Western Victoria, or Brassicas and cereals in the South, North, and East. There are now some established benchmarks regarding direct harvest feed levels on dairy farms; this is directly linked to lower costs and higher profit per kilogram of milk solids.

Profitable dairy farms generally involve:

- Very efficient people
- Efficient cows (milk solids in proportion to live weight) with 300 day lactations
- Efficient hectares (high pasture consumption TDM/Ha relative to rainfall or irrigation)
- High cost control and financial management
- An excellent understanding of marginal economics

The majority of profitable dairy farms are seasonal. **Too often, high cost of production farms believe the cost issue is related to seasonality, when, in fact, it might be simply an inherent high cost of production system.**

Table 1. ONFARM Data for High Profit Farms in 2011/2012 (All very 'seasonal')

Location	Calving	COP* $/kg MS	Profit $/kg MS	Return on Asset 2011/2012	Comment
Kiewa (NE)	Single 20/3	$3.34	$2.01	13.7%	Brown soil; harsh Dec –Apr; high winter growth rates; rape and rye.
Milawa (NE)	Split 1/8, 1/3	$4.53	$1.67	10.2%	30% of milking area irrigated; split calving enables feed efficiency gains.
Yanakie (Gipps)	Single 8/4	$4.47	$0.99	8.7%	Excellent winter growth rates.
Foster (Gipps)	Single 15/7	$4.38	$1.53	10.3%	Grey, pugging soil; reasonable summer growth rates.
Warrnambool (West Vic)	Split 1/3, 20/7	$3.90	$2.61	9.5%	100 ha coastal sandy dryland; 109 ha irrigated.
Corryong (NE)	Split 10/3, 1/8	$3.83	$2.41	14.7%	20% irrigated.
Bena (Gipps)	Single 10/7	$3.62	$2.33	9.0 %	Grey, pugging soil; hill country.
	AV	**$4.32**	**$1.93**		

COP or Cost of Production refers to the total cost of production, which includes farm working expenses (Farm Working Expenses = Herd, Shed, Feed, Overheads, Paid labour), plus imputed operator labour and depreciation.

A fundamental business principle, on which they all operate, is that they will maximise home grown feed consumption (especially direct harvest feed) and have a milk supply pattern which suits their farm, not necessarily their processor.

Myth Busters

Two important studies were completed in the past year, reviewing cost of production data in relation to out of season milk production (Hauser and Lane), funded by Dairy Australia, and cost of production in relation to calving date and frequency (ONFARM), funded by Fonterra Australia.

Myth 1: Multiple calving or autumn calving has a higher cost of production

Across 156 data sets and multiple years there was no statistical difference between the three calving periods in relation to cost of production and the levels of imported feed (ONFARM). Some of the split calving herds had a peak to trough milk flow ratio of 1.25 - not completely flat, but very close.

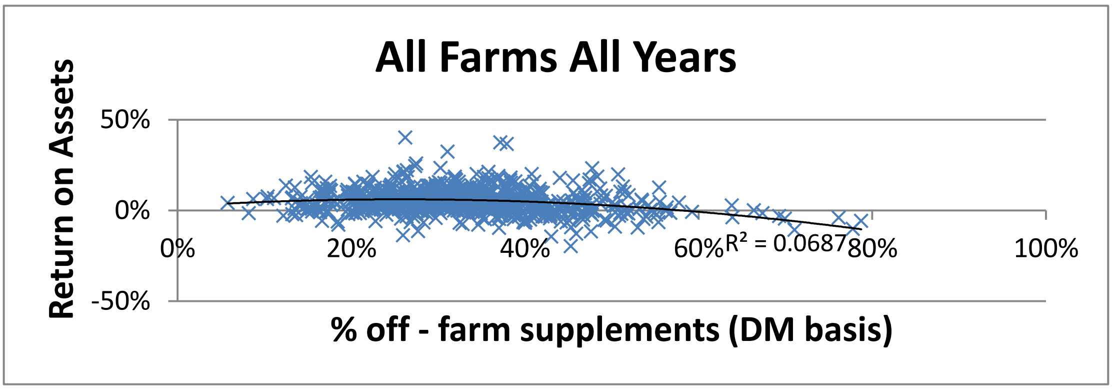
Myth 2: Farms which produce a high level of off peak milk have a higher cost of production

416 data sets were analysed and the conclusions were *'….operating cost, total capital employed, return on capital do not show any particular trend as off peak milk % increases...'*

The data suggests that seasonality of milk production does not contribute to cost of production to the extent that was commonly believed. In fact, some farms simply have a high cost of production, irrespective of when they produce milk.

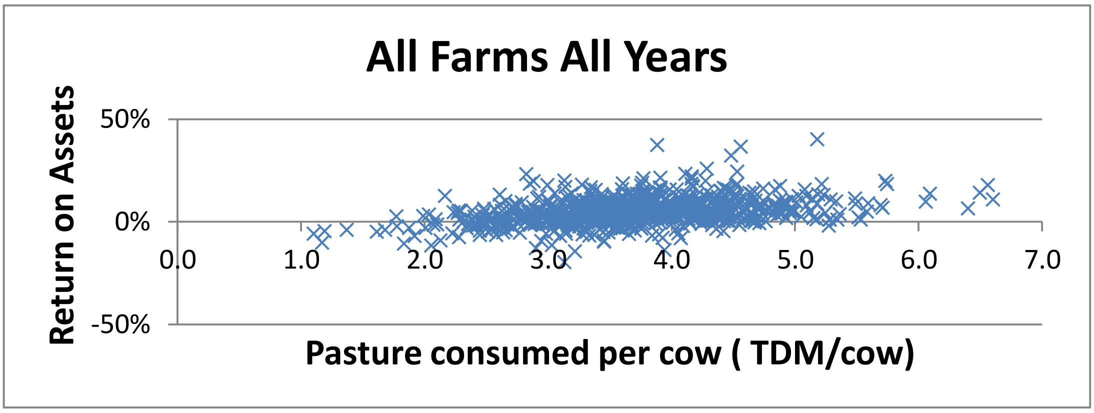
The ONFARM data also confirmed the importance of directly grazed feed and the level of imported supplement being correlated with profit as shown by the following graphs.

Relationship between return on assets and use of off-farm supplement



There seems to be a high prevalence of high profit farms between 20 and 40% re off farm supplements and a low prevalence of high profit farms above 50%. Note: Return on Assets above 20% will normally involve a lessee rather than a farm owner.

Relationship between return on assets and pasture consumption/cow



There appears to be a high prevalence of low profit farms below 3 T DM/cow pasture consumption.

To highlight the relative importance of seasonality and management in regard to Cost of production consider the following modelled changes from Optimum for well managed dairy farm.

Table 2. One farm changing from optimum (All scenarios at $5.50 per kg MS)

Scenario	Return on Asset %	Profit as $/kg MS	Cost of Production $/kg MS	% Imported Feed	Pasture consumption /cow	Labour efficiency Kg MS/ 50hr labour unit
Optimum	10.5%	$1.65	$4.18	37.6%	3.7 T	67,250 kg (125 cows)
Split	8.8%	$1.39	$4.43	37.6%	3.7 T	60,605 kg (113 cows)
Single calving March/April	7.5%	$1.17	$4.65	47.6%	3.2 T	64,491 kg (119 cows)
Overfeed supplements/ underutilise pasture	5.9%	$0.93	$4.89	51.5%	3.0 T	62,680 kg (117 cows)
Reduced labour efficiency plus overfeeding of supplements and under use of pasture	3.9%	$0.61	$5.21	51.5%	3.0 T	46,457 kg (87 cows)
Overhead hemorrhage, poor cost control, reduced labour efficiency, overfeeding of supp. and under use of pasture	1.3%	$0.20	$5.63	51.5%	3.0 T	46,451 (87 cows)

Despite this data being 'modelled' from the actual optimum position, the outcomes are well within measured ranges in the ONFARM data set for differences between farms.

The Internal Business Response - What Can the Individual Business Do?

Through periods of external volatility, it became evident that there was a set of farm business characteristics that would 'protect' the business in extremely volatile times. These indicate the only internal response possible unless the external volatility can be removed. This profile is not just about profit or benchmarking; it is the total business picture. It is not just a financial profile but has to incorporate the physical profile of the business as well, given the seasonal variations businesses are exposed to in Australia.

The 'tower' needs to be balanced to be resilient and each brick in the tower represents a business characteristic. All dairy businesses can be analysed via the tower; it very clearly indicates to the business owners the exposure to risk. In regard to NSW:

Table 3. The Profitable Dairy Business Tower – a general physical and financial profile of a profitable dairy business

Top 40% management skills
3.0 – 4.0 T dry matter/cow home grown milking area feed; no more than 25% of this as silage
Less than 40% imported feed, especially purchased
TM 200 Rating Total Milker Feed \$200/ T DM (\$2.00/kg MS)
Farm Working Expenses (excl. labour) at \$3.50/kg MS (25c/L) (C.O.P \$5.20/kg MS or 37.5 c/L)
Equity in total assets 65%; less than 20% debt in short term debt; FMDs used
Debt servicing less than \$1.00/kg MS or \$500/cow (7 c/L)
Significant owner-operator labour; less than 40% paid labour

Brief explanation of each brick:

- A top 40% dairy management skill is required unless there is virtually no debt and no imported feed. This can make a difference of \$2.00/kg MS (16 c/L)
- The 30 - 40% zone for imported feed appears to be a balance between maximising profit by using supplements to assist in maintaining a higher than average stocking rate compared to lower or no supplement levels at a lower stocking rate to reduce the risk of supplement exposure.
- 3.0 - 4.0 Tonne of dry matter per cow from the milking platform, mainly as grazed pasture or crop, reduces dependency on imported feed per cow and also reduces the average feed cost per tonne of dry matter. This is a ‘national guide’ for anyone operating a pasture based system.
- TM 200 is an ‘ideal’ figure for the cost of feed per tonne dry matter to feed a milker. If the balance between pasture at \$100/TDM, grain @\$370/TDM, and hay or silage, at \$200/TDM is correct then \$200 per tonne dry matter will be achieved, so feed costs per kg MS will be low. A combination of high stocking rates, low pasture consumption, high per cow production, and poor matching of pasture growth to feed demands will cause this figure to be unacceptably high.
- Farm working expenses of \$3.50/kg MS (excluding labour and depreciation) reflects a low cost resilient farm business, and generally a business that has matched herd requirements to pasture/forage growth very well.
- Equity of 65% is desirable, but clearly young farmers encountering first farm purchase will be closer to 40%. It means that they have to be even better at other tower characteristics.

- Debt servicing in many ways is more important than equity. At less than $1.00/kg MS ($500/cow) the business should be resilient, at $2.00 per kg MS ($1,000/cow) the operator needs to be on the top 10% not 40%.
- Less than 40% of total labour as owner operator labour is not necessarily undesirable from a business perspective but there is no doubt that high levels of employed labour reduces flexibility in tough seasons and increases cash costs.

There is a significant proportion of the Australian Dairy Industry (as evidenced by DFM, and ONFARM data) that, for whatever reason, have ‘unbalanced’ towers. Milk price is currently propping up many tilting towers, but to the observer you would never know.

After 30 years in the dairy industry, I believe that the ‘tower’ clearly reflects the difference between businesses that grow, replicate or invest elsewhere and those that lurch from lower to higher milk price periods, struggle with cash flow and rely on the realisation of capital

John Mulvany

Director
ONFARM Consulting Pty Ltd


PGG Wrightson Seeds
THE SECRET TO GREAT
DAIRY PASTURE
IS A GOOD BASE
Base
Australian bred under tough conditions, Base AR37 is resistant to a number of Australia's major pasture pests and is well suited to high-rainfall dairy regions.
• Excellent yielding tetraploid perennial ryegrass
• Exceptional cool season yields
• Stunning late spring quality
• Excellent tiller density
Your dairy production starts here. You expect outstanding performance from a new grass and Base tetraploid perennial ryegrass with AR37 endophyte delivers everything you need. With excellent yield, Base is well utilised and encourages better animal performance. Late heading (+22 days) for stunning late spring quality. Another innovative product from PGG Wrightson Seeds internationally acclaimed tetraploid ryegrass breeding programme.
For further information on Base AR37
visit pggwrightsonseeds.com.au
or call us on 1800 619 910
for free planning advice from a
PGG Wrightson Seeds Agromomist
Base
tetraploid perennial ryegrass
performance bred®
AR37
grasslanz endophyte
pggwrightsonseeds.com.au

LOOKING AT THE NSW DAIRY INDUSTRY THROUGH THE DAIRY FARM MONITOR PROJECT

Kerry Kempton

Technical Specialist Dairy
NSW Department of Primary Industries

Key Messages

The NSW Dairy Farm Monitor Project is now up and running and set to become an annual service to industry, and is a key role for NSW Department of Primary Industries. NSW has a very diverse dairy industry, with a range of farm systems and use of resources. Within the DFMP participants, there is a large variation in many of the key performance indicators, so averages can be misleading.

The top farmers as measured by return on assets, do most things right, they don't top every category but they are close in most of the key ones. They produced more milk per hectare and controlled their overhead costs better than the average of the whole group.

The 2012/13 year was a tough one and farm profits were lower than the previous year. A combination of lower milk prices and higher production costs left smaller margins and minimal return on assets for many farms in the project. Seasonal conditions were not favourable overall.

The participating farmers were asked about their intentions for the next 12 months and five years. Almost three quarters of farmers expect their farm business returns to improve in 2013/14; as the majority of farmers anticipate improved milk prices and decline in some input costs in 2013/14.

Declining terms of trade, labour issues and seasonal conditions were the top three issues farms identified that would have the biggest impact over the next 12 months. Over the longer term labour management, succession planning and milk prices were front of mind for participant farmers. A number of farms also indicated that they are positive for the long term future of the industry, especially following the entry of Murray Goulburn into the NSW liquid milk market.

Background

The NSW Dairy Farm Monitor Project (DFMP) has been established by NSW Department of Primary Industries (DPI) as a service to the industry, to provide accurate reliable information about dairy farm performance. The project has been running for two years and will continue on an annual basis.

The NSW project is part of a nationwide initiative funded by Dairy Australia, to provide valuable accurate farm level data each year about production and profitability, and to identify the main drivers of productivity and profit, for the NSW and Australian dairy industry to grow and thrive.

DPI is working in close collaboration with Dairy Australia and Victorian Department of Environment and Primary Industries (DEPI) to deliver this project. This NSW DFM project has been modelled on the successful Victorian DEPI project, which has now been operating for seven years. The information generated by the project is highly valued by the dairy industry, agribusiness and government.

Prior to the commencement of DFMP, there was very limited discussion and information on farm business management in NSW, at all levels of industry. There were no benchmarking schemes operating and very little available data on profitability in our industry. NSW DPI dairy extension officers had been active in providing business analysis for individual farmers through the Milk Biz program, but there was no comparative analysis or publishing of results.

In response to this lack of information the NSW Dairy Farm Monitor Project was initiated to provide current economic, social and environmental data which will enable NSW DPI, Dairy Australia and the NSW Dairy Industry to:

- Obtain objective and rigorous financial and production data relating to dairy farm performance in a timely manner on an annual basis
- Monitor the changes in the profitability and production of dairy farmers on both a regional and statewide basis over time
- Understand the issues and industry concerns of farming families
- Measure the on-farm impacts of research and extension projects
- Measure the greenhouse gas emissions generated by milk production

The participating farmers benefit from their involvement through gaining a better understanding of their business performance, and developing farm business management culture. They are provided with a report detailing their farm data, compared with previous years and with the average of the group. The participating farmers are identified only by a number and their details are confidential, therefore we cannot profile the farmers or describe their farm systems in detail.

About the farms

A general offer was made initially to all NSW dairy farmers requesting expressions of interest in the project; with the key selection criteria being that they were willing to share their data with industry, and that they kept very good records. Interested participants were then selected with the objective of representing a distribution of farm sizes, herd sizes and geographical locations within the state. There have been 28 farms involved each year, from across the whole of NSW, with almost every dairying region represented. They are not exactly the same farms each year, with three farmers leaving and a new three joining over the first two years.

The farms range in size from 100 hectares to 1500 ha, and herd size ranges from 150 to 1000 cows in milk, including Jersey, Crossbred and Holstein herds. Milk production ranges from 336 to 600 kgs milk solids per cow (4400 to 8800 litres /cow), and there are a range of feeding systems from very low to very high input. There are farms from high rainfall coastal regions to the southern Riverina irrigated farms; and farmers at differing stages on the business life cycle.

The participating farms have been allocated into two groups for analysis and reporting: the North and the South. Whilst this grouping reflects general similarities among farm systems, and the influences on milk pricing across NSW, there is still a large geographical spread of farms within each group and a wide range of regional differences in terms of climate and resources.

Table 1. Average farm physical data – state overview

Farm physical parameters	Statewide	North	South
Number of farms in sample	28	14	14
Herd size (max no. cows milked for at least 3 months)	349	361	337
Annual rainfall 12/13	876	1,174	579
Water used (irrigation + rainfall) (mm/ha)	1,064	1,323	805
Total usable area (hectares)	329	335	323
Stocking rate (milking cows per usable hectares)	1.2	1.3	1.1
Milk sold (kg MS /cow)	492	460	523
Milk sold (kg MS /ha)	608	615	601
Milk price received ($/kg MS)	$6.43	$6.83	$6.03
Milk price received (c/l)	46.4	49.3	43.5
Labour efficiency (milking cows / FTE)	76	69	82
Labour efficiency (kg MS / FTE)	37,384	32,222	42,545

The results published in the annual report should not be taken to represent population averages as the participant farms were not selected via random population sampling. The farms in the project are larger than average for the rest of the NSW industry, which is around 250 ha milking 268 cows.

Dairy Farm Monitor Methodology

The methodology employed to generate the profitability and productivity data in this report was adapted from that described in The Farming Game (Malcolm *et al*. 2005) and is consistent with that used in the Victorian Dairy Farm Monitor Project reports. Readers should be aware that not all benchmarking programs use the same methodology or terminology for farm financial reporting. The allocation of items such as lease costs, overhead costs or imputed labour costs against the farm enterprises will vary between financial benchmarking programs. Standard dollar values for stock and feed on hand and imputed labour rates may also vary. For this reason, the results from different benchmarking programs should be compared with caution. Figure 1 below shows how the farms are analysed and reported, with the average results for 2012/13 across all the farms shown.

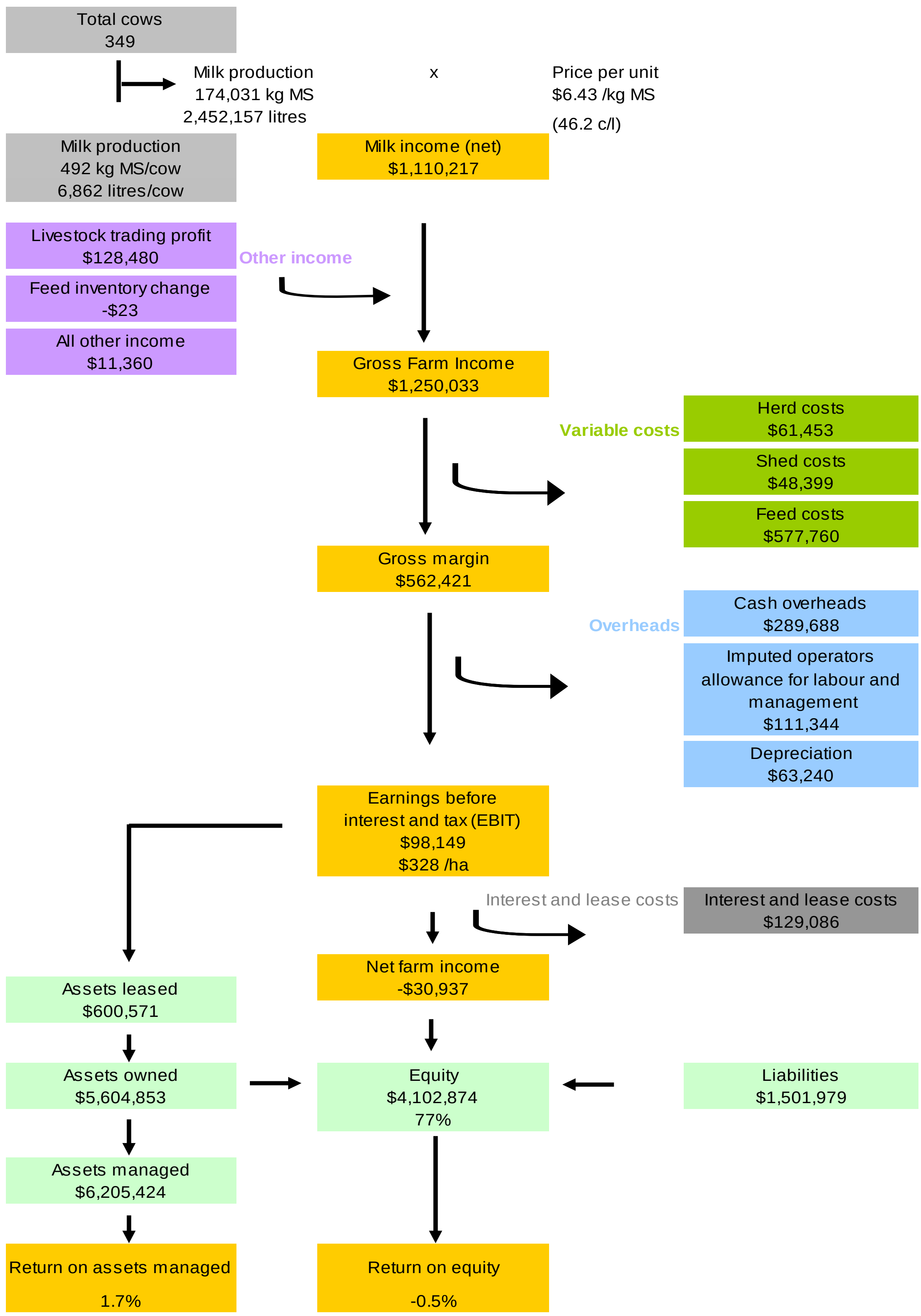


Figure 1. DFMP method profit map – NSW state average data for 2012/13.

Results

The 2012/13 financial year was one of the toughest years experienced by dairy farmers for some time, and this is reflected in the results from the DFMP. Variable seasonal conditions and lower milk prices were the main influences on farm profitability in NSW. Across the North, farms experienced extremes of very dry conditions followed by record rainfall events in summer 2013. In contrast the South had average rainfall and then became dry in the second half of the year.

Input costs rose primarily driven by a 35% increase in fodder purchases as farmers attempted to manage the extremes in rainfall. Milk prices declined by around 7% from FY11/12 with the average price received across all farms $6.43 / kilogram of milk solids (46 cents/litre), down from $6.88 /kg MS (49 c/l) for the previous year. These challenging conditions resulted in average whole farm earnings before interest and tax (EBIT) falling significantly on the previous year, to $98,149 while average return on assets were only 1.7%.

For many farmers in the North, this was the fourth or fifth consecutive year where they have experienced damaging floods, and this places a huge strain on people physically, emotionally and financially. This has been exacerbated by a 4% decline in milk price received during 2012/13, particularly during the spring when two tiered milk prices were in play. Cost of production increased slightly on last year, as the higher prices for purchased feed generally offset any cost cutting in other areas.This led to a drop in net farm income to -$89,706 and seven of the 14 farms recorded negative net farm income.Across the South region, milk price fell 9% due to the weaker Victorian milk prices. Processors sent clear market signals against oversupply of milk in spring and summer, resulting in both lower milk production and income in 2012/13 than last year. Farms experienced average rainfall during the first half of the year, and then a fairly dry second half.

Fodder was expensive, increasing 26% to $220/t DM for purchased hay, and hard to source. The late frosts and lack of moisture impacted on the grain harvest increasing the price of concentrates to $311/t DM on average. The reduced gross income due to lower milk prices, plus higher costs of production especially in purchased fodder and grain costs, has contributed to the decline in farm returns. Net farm income fell to $27,832 with seven of the 14 farms recording negative net farm income for the financial year.

Table 1. Main financial indicators for 2012/13.

Averages, Top 25% and Ranges							
Appendix table 1 - Main financial indicators				The middle 50% of participants are in this range			
		Average	Top 25%	Q1	Q3	Minimum	Maximum
Milk income (net)	c/litre	46.42	45.30	42.93	50.90	35.88	57.78
All other income	c/litre	5.54	6.97	3.03	7.36	0.25	17.97
Total income	c/litre	51.97	52.27	46.67	58.71	39.88	65.90
Total variable costs	c/litre	27.24	26.63	23.67	29.92	19.44	41.47
Total overhead costs	c/litre	21.00	17.61	16.41	25.85	11.78	32.86
Cost structure (variable costs / total costs)	%	57%	60%	52%	61%	43%	69%
Earnings before interest & tax	c/litre	3.73	8.03	1.36	5.30	-10.03	17.05
Return on assets (excl. capital appreciation)	%	1.7%	5.0%	0.0%	2.8%	-3.6%	9.4%
Interest & lease charges	c/litre	4.39	3.85	1.66	5.91	-	15.70
Debt servicing ratio	% of income	8.7%	7.6%	3.0%	12.6%	0.0%	31.5%
Net farm income	c/litre	-0.67	4.18	-4.48	3.15	-13.27	11.97
Return on equity	%	-0.5%	3.6%	-2.0%	1.7%	-8.4%	10.0%
Return on equity (incl. capital apprec.)	%	-0.8%	2.9%	-3.0%	1.7%	-8.2%	9.0%

Table 2. Main Physical indicators for 2012/13

Averages, Top 25% and Ranges		Average	Top 25%	The middle 50% are in this range Q1	Q3	Minimum	Maximum
Total usable area	ha	329	264	194	315	95	1,569
Milking area	ha	140	115	96	157	50	450
Water used	mm/ha	1,054	1,004	764	1,267	490	2,383
Number of milking cows	hd	355	329	234	413	155	1,036
Milking cows per usable area	hd/ha	1.24	1.34	0.91	1.43	0.61	2.63
Milk sold	kg MS /cow	492	531	455	530	336	601
Milk sold	litre /cow	6,862	7,394	6,107	7,597	4,404	8,771
Fat	%	3.9%	3.8%	4.0%	4.1%	3.2%	4.8%
Protein	%	3.3%	3.4%	3.0%	3.4%	3.1%	3.9%
Estimated grazed pasture*	t DM /ha	6.9	7.2	5.5	8.8	2.2	11.8
Estimated conserved feed*	t DM /ha	1.3	1.7	0.3	1.4	-	8.9
Home grown feed as % of ME consumed	% of ME	56%	52%	53%	65%	17%	71%
Labour productivity	cow/ FTE	76	81	63	85	49	132
Purchased feed per milker	t DM/hd	2.3	2.7	1.7	2.7	0.8	4.5
Concentrate price	$/ t DM	323	322	284	361	203	462
Hay price	$/ t DM	246	252	206	294	127	384
Average purchased feed price	$/ t DM	312	305	277	354	187	453
Percent of total energy imported	% of ME	44%	48%	35%	47%	29%	83%
* On the milking area							

Return on Assets

The return on assets is the earnings before interest & tax (EBIT) expressed as a percentage of total farm assets under management and hence is an indicator of the earning power of total assets, irrespective of capital structure. Similarly, it can be considered as an indicator of the overall efficiency of use of the resources that are involved in this production system and not elsewhere in the economy. Return on assets is used to identify the top 25% of farms in the project. The average return on assets for participants across the state was lower than the previous year, down from 4.3% in 2011/12 to 1.7% in 2012/13, with a range from -3.6% to 9.4%. Twenty four of the 28 participant farms had a positive return on assets, while the remaining two farms reported a return on assets of between zero and -0.5 per cent.

The market value of land varied widely across the 28 farms in the group, according to location and land capability. Values for livestock and permanent water rights have been standardised across all farms at market value.

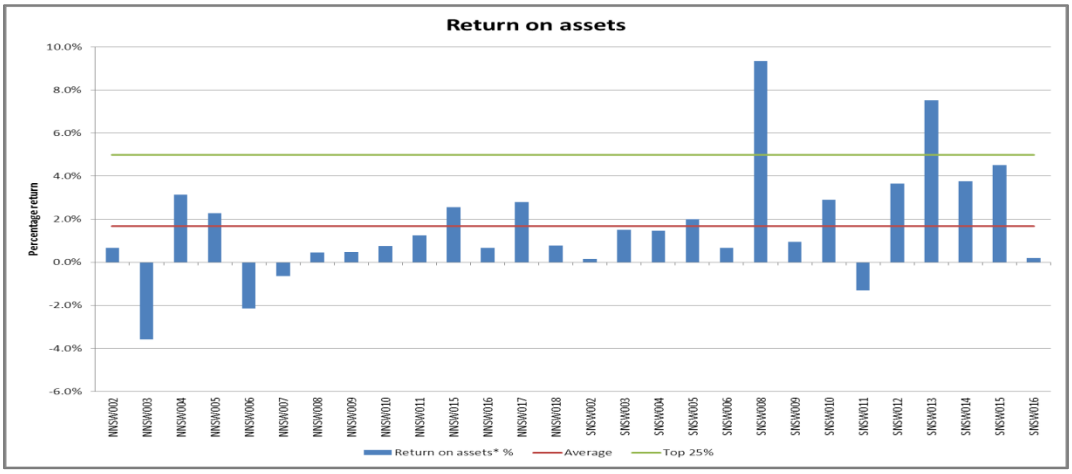


Figure 2. Return on assets for all farms 2012/13

Earnings before interest and tax (EBIT)

Earnings before interest and tax (EBIT) are the gross farm income, less variable costs and overhead costs including non-cash costs. As this figure excludes tax and interest and lease costs, it can be used to analyse the operational efficiency of the whole farm business.

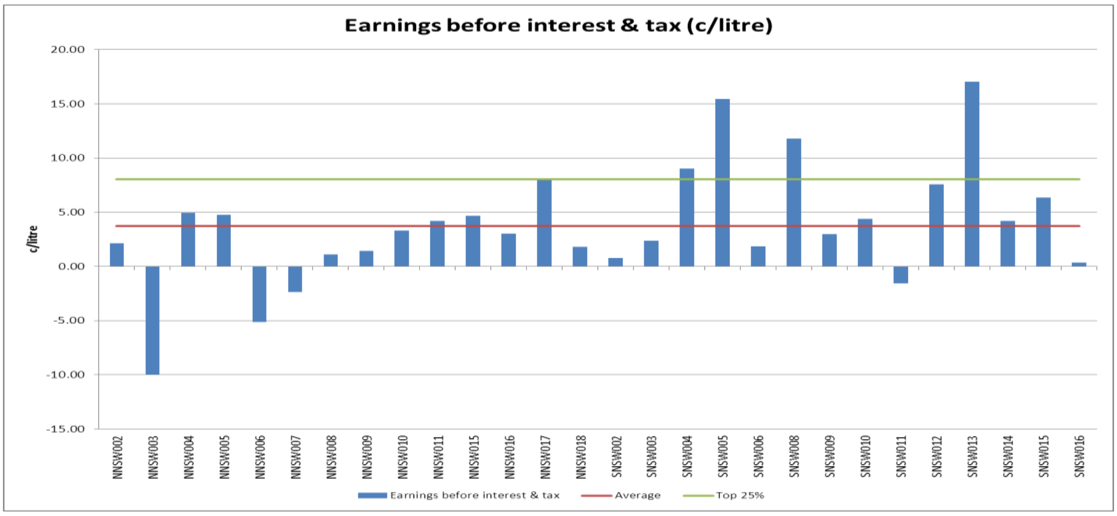


Figure 3. Earnings before interest and tax (EBIT) in cents/litre for all farms 2012/13

Feed utilisation

The DFMP analysis provides an estimate of tonnes of home grown feed consumed per milking hectare. The average estimate for all farms was just over 8 tonnes DM/ha as grazed feed and conserved feed. The graph below accounts only for the consumption of pasture that occurred on the milking area whether by milking, dry or young stock.

Several of the farms in the project grow fodder crops for silage or grain on the non-milking area. These tonnages are calculated as part of the total feed produced on the farm usable area, but may not be captured as home grown feed on the milking area. So some farms may appear as low consumers of pasture, but may also grow more fodder over the whole farm.

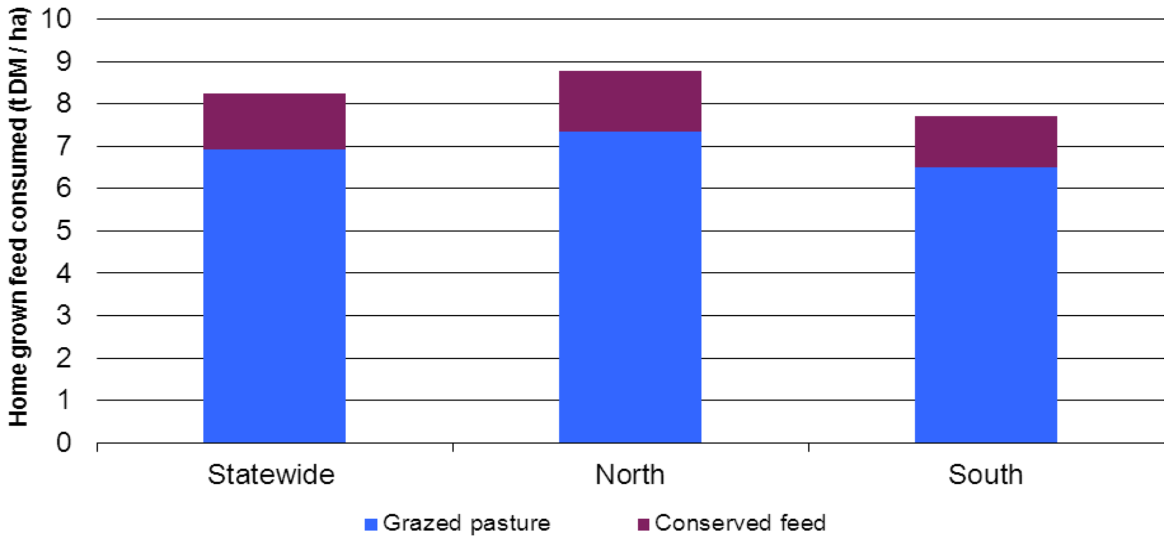


Figure 4. Estimated home grown feed consumer per hectare on the milking area.

Difference between top 25% farms and the average

The farms are ranked on return on assets, with the top 25% of farms identified and compared to the group average on some key financial and physical indicators. Some of the key traits of the most profitable farms in the group are:

They have smaller farm area and milk fewer cows than the average, but produce more milk per cow (7400 l/cow vs the average of 6800 l/cow) and per hectare (10000 litres/ha vs the average of 8500 litres/ha).

Their cows consume more feed, both home grown and purchased, to produce this extra milk, but their feed costs were not significantly higher.

The main difference in financial performance was in lower Overhead costs in the top 25% group, by around 3.5 c/l. This includes labour and repairs and maintenance, and depreciation.

The milk income and variable costs were very similar between the groups, indicating that higher milk price does not necessarily lead to higher profit.

For more information about the project and to access the Annual Report, visit the Dairy Australia website: http://www.dairyaustralia.com.au/Business-and-financials/NSW-Dairy-Farm-Monitor-Project.aspx

Kerry Kempton
NSW DPI, Tocal Agricultural Centre, Paterson, NSW 2421
Phone: 02 49398945
Email: kerry.kempton@dpi.nsw.gov.au

DEVONDALE
MURRAY GOULBURN
Proud sponsor of
Dairy Research Foundation
Symposium 2014
www.mgc.com.au

DAIRY FARMER Z

Cameron Clark

Dairy Science Group
Faculty of Veterinary Science
The University of Sydney, Camden (2570), NSW; Australia

Introduction

Consumers are increasingly demanding high quality dairy products produced at very high standards of animal wellbeing. In this same environment, cow numbers per farm continue to increase with a trend emerging to very large farm operations of over 1,000 head (Dairy Australia, 2013) in systems where farmers are already working long (>60 hours per week) hours (DFMP, 2008). Technology and associated systems that reduce repetitive tasks and focus valuable farmer time to animals and tasks that require attention will become increasingly important and prevalent in the future. These systems are not only important to enable more timely and informed management decisions but to also increase the attractiveness of the Industry for the next generation of farmers which will be retained from the country and sourced from the ever closer city. This next generation of farmers "Generation Z" never knew a world without the internet is soon to turn 20 and are well on their way to making a contribution to the workforce, if they aren't already in leadership positions. Generation Z eats technology for breakfast and dines out on handling multiple sources of data at once, a very important trait for the modern dairy farm.

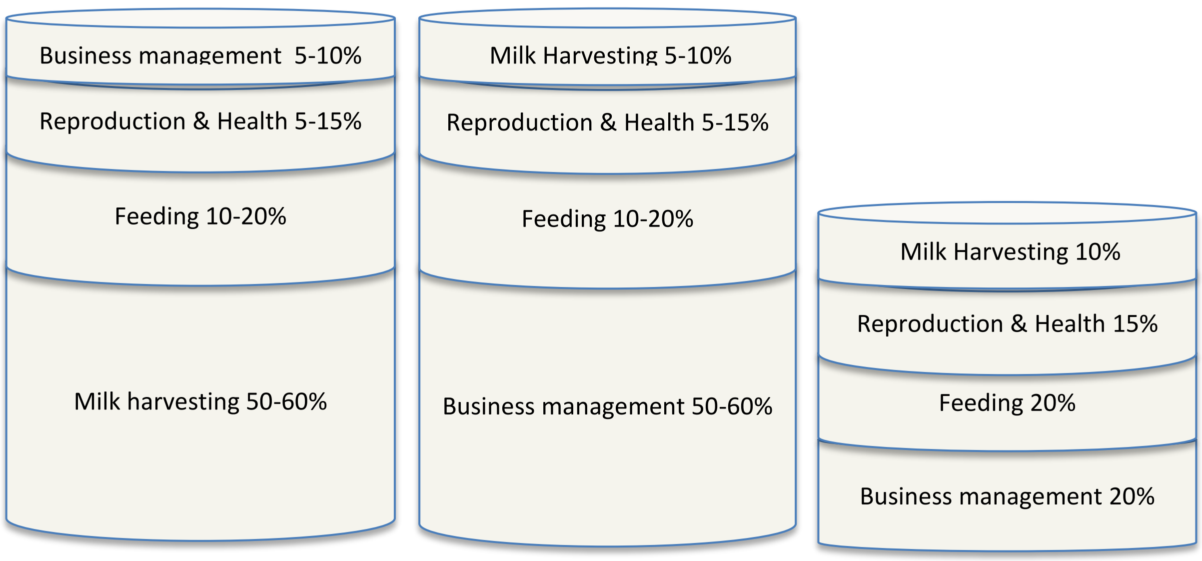


Figure 1. The percentage of the day spent conducting tasks for the current dairy farmer (left) and Famer Z (middle or right).

Ways to interpret data generated by new technology and turn it into information that current and 'Z' farmers can use to increase profitability and improve cow health, alongside methods to decrease repetitive tasks are key areas of research for the Dairy Science Group.

In essence, the group is providing ways of inverting the time bucket for current dairy farmers, providing options to increase the time available for business management and/or time outside of dairying whilst improving productivity and maintaining or improving animal health (Figure 1).

This manuscript provides detail on this time bucket for Farmer Z, bringing together Dairy Science Group research that has been conducted with other technology that is on our doorstep.

A dairy farming day for Farmer Z

Morning

- Z wakes up at 7am and checks reports on cow and automatic milking system performance. The system reports that 7 cows have been capture by the auto drafting gates in the yards.

- 5 of these cows have been captured based on activity and rumination data obtained from sensors within a collar on the cow (Figure 1) which provided the hour that the cow started to stand to be mounted.

Figure 1. An activity and rumination sensor collar that records sound and acceleration of the cow real-time 24 hours a day. These data are sent remotely to the dairy where they are collated and interpreted by software.

- Mating has been prioritised for between 9-11am to enhance the chances of conception based on research showing the optimal timing of insemination from the start of standing to be mounted. A range of semen has been purchased by Z and the system has chosen the best match between bull and cow based on predicted optimal phenotypic outcomes from the combination of respective genes. Z quickly looks over the activity levels as a check of the system and pulls up the activity graph for each cow. Cows that have lower than usual level of activity associated with oestrus have their rumination level pulled up as Z knows that cows on heat have a decline intake and reduced rumination levels.

- Alongside these 5 cows in the yards are 2 cows that have rapidly decreasing rumination levels and low milk yields at the previous milking. The veterinarian has been called by the system to check these cows. Z found that the last cow with a left displaced abomasum was identified 5 days earlier than predicted using observations and a sustained drop in yield (Figure 2). As this cow was picked up earlier for treatment, recovery of health and milk production was much quicker.

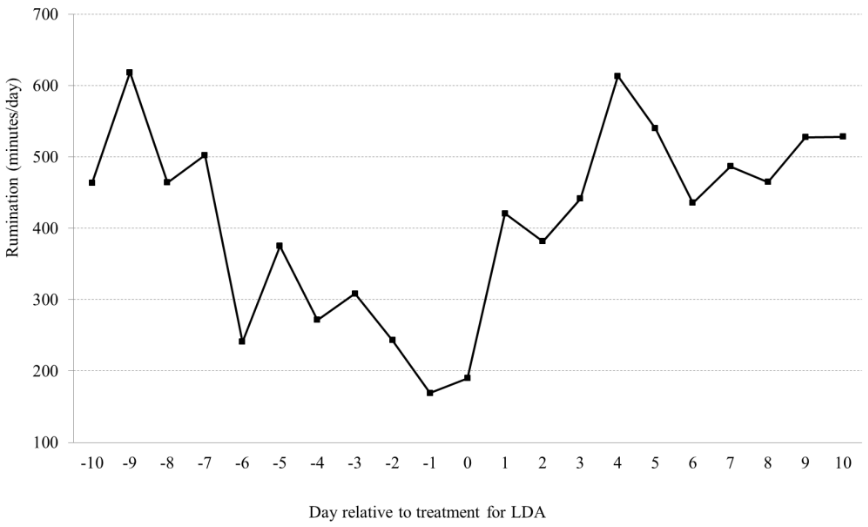


Figure 2. The drop in rumination levels associated with a left-displace abomasum. Day '0' is the day of treatment. There is a clear decline in the level of rumination around 5 days before the day of treatment.

- Cows are fetched from paddocks that have not come up from yesterday's allocation of pasture by an unmanned ground vehicle (UGV) (Figure 3).

Figure 3. The Dairy Science Group has shown the ability to remotely herd dairy cows from a paddock (Clark *et al*., 2013) and has recently purchased a UGV more designed for the job. This new UGV will be housed at the University of Sydney dairy farm and will provide a platform to test multiple sensors, conduct numerous tasks and collect information across 24 hours.

- These 9 cows that are fetched are scanned by a camera upon entry to the dairy to check for lameness by comparing that specific cow's historic movement pattern with current movement. Cows with abnormal patterns are auto drafted after milking and an alert is sent to Z.
- After uploading the details of these cows onto the phone, Z has breakfast.

Breakfast break

- Z cleans the yards and milking robot, and then inseminates the 5 cows with sexed semen. Feeding and milk production reports are then checked. Through the night the UGV has determined pasture covers and has obtained soil cores on a per metre basis across the farm. These pasture covers are used to determine today's pasture allocation based on predicted growth rates for each metre of the farm given the variability between areas in terms of growth despite best practice management as shown by Dairy Science Group research (Garcia *et al*., 2014). Fences are set by Z but the time is coming where virtual fences will eliminate all internal fencing.

- The soil cores are analysed for N, P, K, S and predicted feed budgets are used together with climatic data to determine the fertiliser which is reapplied by the UGV on a per metre basis across the farm.

Afternoon break

- A calving alert is received by Z for 2 cows that the system has been 'watching' based on a decline in rumination levels (Figure 4).

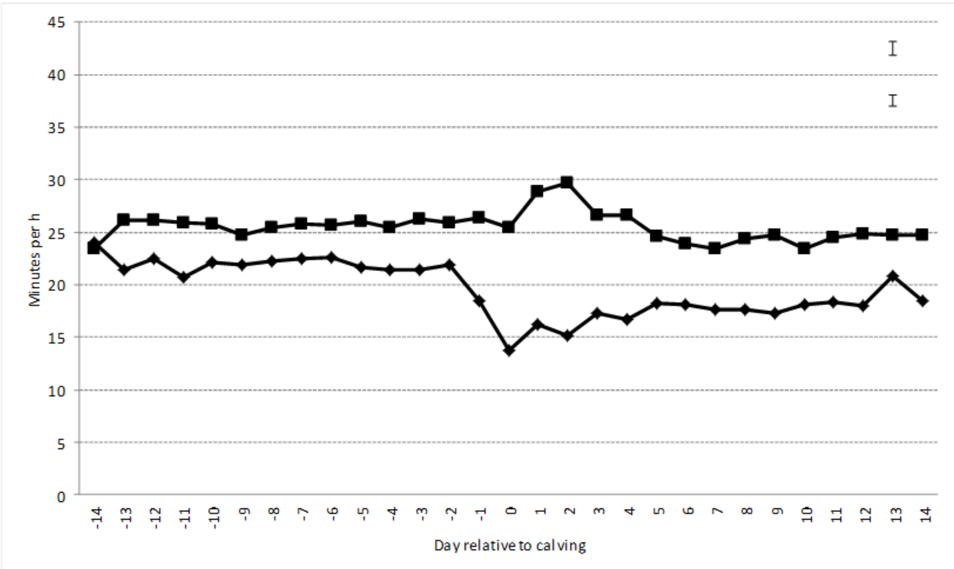


Figure 4. Average levels of rumination (diamonds) and activity (square) for 27 cows relative to the day of calving (0) taken from Dairy Science Group research.
There is a clear decline in rumination levels the day before calving highlighting the ability to identify the cows that are going to calve tomorrow. Future research will determine the ability to predict the time of calving within a day together with the use of activity and rumination profiles after calving to determine the health of the cow.
Also the ability to determine abnormal behaviour profiles leading up to calving to predict the likelihood of a calf being born without intervention will be determined.

- Z spends the rest of the afternoon looking at forecasted climate data and the trends in feed prices, speaking to rural professionals over the internet on farm performance and getting across the farm to pick up on anything that the system has missed. Information is then fed back into the system by Z and a report is sent back to the engineers for a system update.

- New feed prices are entered into the system and the amount of supplementary feed offered altered to optimise the profitability of the system whilst maintaining (or improving) animal health. Supplementary feeds are now formulated based on what each cow is predicted to eat to markedly increase feed conversion efficiency given the variability both across pasture swards and also down the sward (Figure 5).

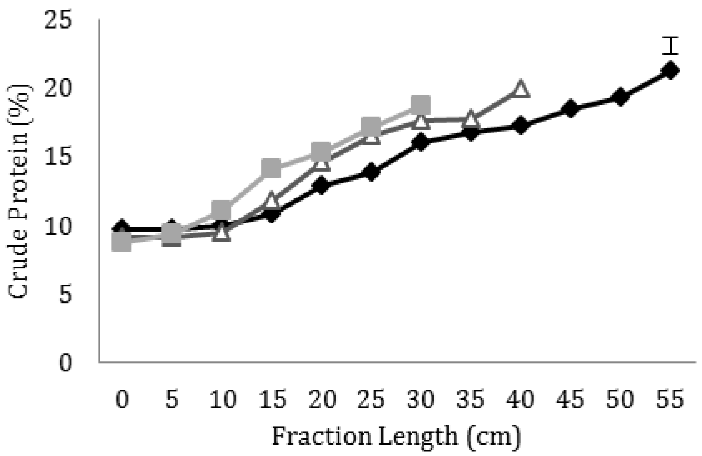


Figure 5. The change in crude protein (%) with increasing height of pasture from ground level. These findings taken from the data of Ms. Beth Scott's honours thesis (USYD) shows the marked change in CP down a pasture sward to ground level (fraction length 0cm).
As cows tend to graze in layers (leaf first down to stubble), the first cows that access an allocation of pasture access CP that is approximately 5% greater than that of the last cows (considering that cows leave a post grazing residual mass).

References

Clark, C.E.F., Garcia, S.C., Kerrisk, K.L., Underwood, J.P., Nieto, J.I., Calleija, M.S., Sukkarieh, S. and Cronin, G.M. (2013). A robot amongst the herd: A pilot investigation regarding the behavioural response of dairy cows. *Proceedings of the 4th Australia and New Zealand Spatially Enabled Livestock Management Symposium*, 26-27 September 2013, Camden, Australia.

Dairy Australia (2013). Australian Dairy Industry in Focus 2013.

DFMP (2008). Dairy Farm Monitor Project 2008.

Garcia, S. C., Clark, C. E. F. Kerrisk, K. L., Islam, M. R., Fariña S. R. and Evans J. (2013) Gaps and variability in pasture utilisation in Australian pasture-based dairy systems. *Proceedings of the 22nd international Grasslands Congress*, 15-19 September, Sydney, Australia.

REALIZING THE HOLY GRAIL OF SEX SELECTION IN THE BOVINE

Michael K Holland

Professor of Animal Biotechnology
School of Veterinary Science
The University of Queensland
Gatton, Qld 4343

Abstract

The goal of being able to select at will the sex of offspring is important across a broad range of species of agricultural importance and increasingly also in areas such as companion animals and even endangered species breeding. Sex selection in our own species is desired by some but is also considered by many, but not all, cultures as unethical and possibly immoral and so is specifically banned in many countries. Basically selecting the sex of offspring can be achieved in two ways: 1) separating sperm bearing the X chromosome (i.e. females) from those bearing the Y chromosome (i.e. males) or 2) determining the sex of the embryo prior to implantation. This is most readily achieved when the embryo is produced as a consequence of in vitro fertilization. Which of these methods is more appropriate depends in part on the species and also on the technology available. In cattle and especially dairy cattle the first option has been favoured in large measure because of the widespread use of artificial insemination for breeding. Whilst it is true that this technology is receiving greater use in the beef industry, especially where beef cattle are raised intensively, in other parts of the World, where beef cattle are raised extensively, use of artificial insemination is less common making sex selection difficult. Notwithstanding this caveat the focus of this small review will be on sex selection in the bovine broadly.

Introduction

Interest in determining the sex of offspring goes back at least as far as the ancient Greeks. Democritus in 470BC suggested that males had two testes because male offspring were derived from sperm produced by the right testis and females from sperm from the left testis. Fortunately this theory does not seem to have led to any testicular amputation experiments in a bid to achieve only offspring of the desired sex! Almost all cultures, including our own current culture, contain elements of folklore about distorting sex ratios but none of these withstand scientific scrutiny (e.g. intercourse close to ovulation favors males because male sperm swim faster, male sperm do better in an alkaline environment thus alter your diet to produce alkaline reproductive secretions, certain positions during intercourse favors males etc). This desire in agriculture and elsewhere for offspring of a specific sex has resulted in scientists identifying theoretical or seeking real differences between male and female sperm. These include physical differences such as size, weight, density, swimming speed, electrical surface charges, differential effects of pH or atmospheric pressure and my personal favourite, differences in proteins present on the sperm surface. However none of these approaches have led to the development of robust, repeatable differences in the sex ratio of offspring and so none have had any commercial impact. However, there are some real differences in sex ratios which suggest either some positive selection for a certain sex is occurring or the alternative, less frequently considered option of selective death of one sex thus increasing the percentage of embryos of the other sex. For examples bovine embryos produced through IVF result in about 54% males whereas artificial insemination or embryo transfer result in only 51% males. Other factors can have influence such as cow age (older cows have slightly more males) and better management systems can favour a slight preponderance of males. These differences serve only to encourage those who seek this holy grail of sex selection.

Current commercial technology

Garner, Evans and Seidel (2013) recently published an excellent methods article on the current procedure of using a combined flow cytometer/cell sorter to separate X and Y bearing sperm in the bovine. The article contains an excellent history of this technology which will not be repeated at length here.

It had long been known that there were differences in size and hence DNA content and by implication differences in weight between X and Y bearing sperm. Indeed this was the basis on which attempts had been made to separate the two sperm populations using centrifugation through different gradients and media. Moruzzi (1979) showed that the difference in chromosome length between bulls and cows was 4.2%. It was felt that this difference could be exploited. The question was how? The answer was provided by Pinkel *et al* (1981) who showed precise measurements of sperm DNA content could be obtained in a flow cytometer. Regrettably, the sperm had to be permeabilized then stained with 40,6 diamindino-2-phenylindole (DAPI) so that whilst the sperm were separated they were dead. However, the method did permit Garner *et al* (1983) to make critical measurements on the difference between X and Y bearing sperm in several bovine breeds (see Table1) reinforcing the potential of this approach.

Cattle Breed	**Difference in DNA content (%)**
Holstein	4.98
Jersey	4.21
Angus	4.05
Hereford	4.05
Bos indicus	3.73

Moving from separating dead sperm to live sperm required the use of a permeant dye that would stain the sperm DNA without subsequent effect on sperm viability or fertility or the health and wellbeing of the offspring. Johnson and co-workers (1987) were the first to report the use of the dye Hoechst 33342 to stain sperm and separate them by cytometry. Johnson and colleagues followed this paper in 1989 with the first paper "Sex preselection in rabbits: live births from X and Y sperm separated by DNA and cell sorting" which established the principle on which commercial bovine sexed sorting is based.There have been many subsequent modifications both to equipment and to sperm preparation and media but the overall method has probably been best described by Garner (Garner *et al*, 2013)."Sperm DNA is stoichiometrically stained with Hoechst 33342, and then the sperm are pumped in a stream in front of a laser beam at specific wavelengths. The illuminated Hoechst 33342 stained sperm emit a very bright blue fluorescence. This fluorescence is rapidly measured using a photomultiplier tube (PMT) as the sperm flow single-file in front of the PMT.

A high speed computer is used to analyze the relative fluorescence of the X- and Y-sperm populations as they flow through the instrument in a fluidic stream. A crystal vibrator is used to break the stream into individual droplets, many of which contain a sperm. The fluorescently stained sperm are sorted by DNA content by placing opposite charges on droplets containing X-sperm from those containing Y-sperm (Fig. 1). The droplets fall past positive and negative electrical fields, and since opposite charges attract, the droplets separate into two streams for collection. A third stream of uncharged droplets is discarded; these droplets have sperm that could not accurately be sexed (over half), no sperm, rarely two sperm, as well as dead sperm. The gating out of dead sperm is a valuable fringe benefit of this process. This sperm sorting technology is known as the Beltsville Sperm Sexing Technology and was patented by the USDA."

The X and Y sperm are collected into media, centrifuged and then suspended into cropreservation media and frozen in the case of cattle in doses appropriate for artificial insemination. Cryopreservation of sexed semen is one area of the technology which has revolutionised the use of sexed semen as it can now be treated just as regular semen and can be distributed to a worldwide market. There is still ongoing work to improve cryopreservation of sexed semen to increase pregnancy rates at first insemination which would improve the economics of use of sexed semen which costs significantly more than normal frozen semen.

Sorting rates were initially a problem that actually meant initially far too long was taken to sort semen for the technology to be commercial. Currently about 10 doses to yield 10 X enriched and 10 Y enriched samples can be sorted per hour with 90% accuracy which is one reason why these machines commercially need to run 24 hours given the commercial demand for sexed semen. The current process in undergoing continual improvement e.g. changes to the nozzles used and to the pressure driving sperm through the machine have reduced sperm damage and thus wastage during sorting making the process even more efficient.

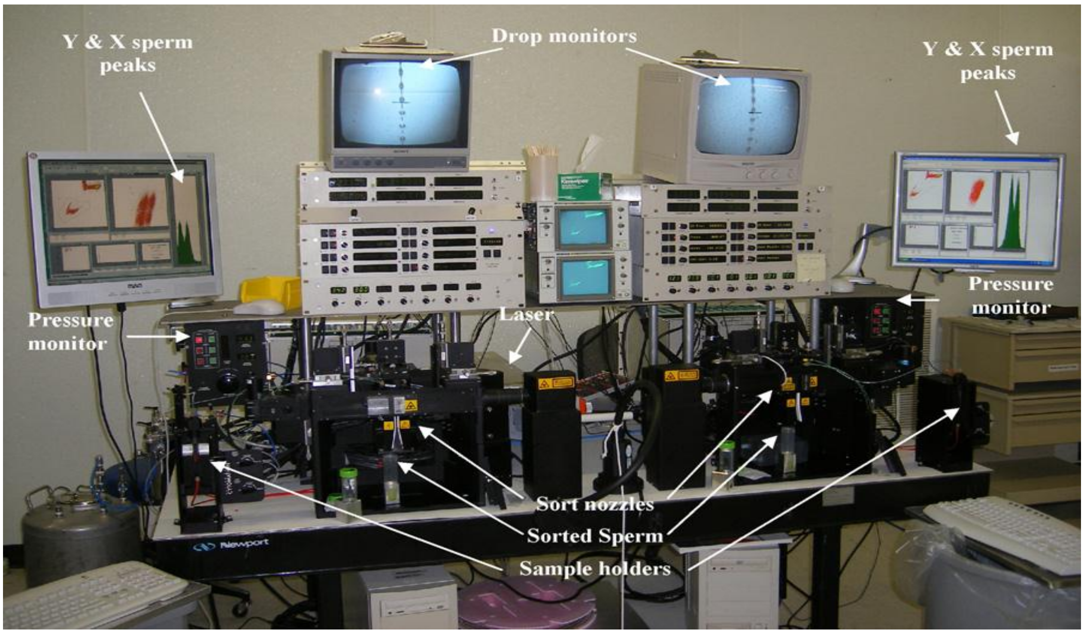


Figure 1. Dual-headed sperm flow cytometer/sperm sorter (Dako MoFlo1 SX) as currently used to commercially sort sexed sperm at Sexing Technologies, Navasota, TX, USA. *The system has been redesigned from the original MoFlo1SX by K. Michael Evans so that the solid-state UV laser beam could be split and directed into two sorting heads (nozzles). This figure is taken from D.Garner and G.Seidel Theriogenology 69 (2008) 886–895*

The use of sexed semen makes economic sense

Despite these improvements in the technology the cost of a bull's sexed semen is often twice the cost of the same bull's unsorted semen. Conception rates remain lower for sexed semen. Sexing Technologies, the leading producer of sexed semen, website suggests you can expect conception rates with sexed semen about 85% of those obtained with conventional semen. The reason for the lower conception rate revolves around the concentration of sperm cells loaded in a conventional semen straw compared to a sexed semen sample. A conventional straw contains 20- 30 million sperm cells whereas there are about 2.0 million sperm cells in a straw of sexed semen. The main problem remains cost. The technology and equipment are expensive and to operate them skilled staff are needed and purpose built facilities are required.

Despite the higher cost and lower conception rates, however, sexed semen can make economic sense. The basic arithmetic is straightforward. Suppose you want more heifers than bull calves because a heifer is worth $1,250 to you and a steer calf weighing 220 kg at $3.90/kg. is worth $825. Use of conventional semen will give you half heifers and half steers. Thus, the average value of calves is $1,037.50 ([50% X $1,250] + [50% X $825]). However use of sexed semen could produce 90% heifers instead. Then the average calf value would be $1,207.50 ([90% X $1,250] + 10% X $825]). This gives an average gender value difference of $170/calf. Economists suggest using sexed semen makes economic sense for beef and dairy producers when the gender value difference is at least $150. That's without considering genetic progress and other indirect values producers may attach to having more calves of one gender than another.

The cost of the sexed semen is small in comparison to the return. To capture this assumes that your pregnancy rate from artificial insemination is good (>80-85%) so you do not have large numbers of empty cows, that you regularly turn off empty cows and that nutrition and general management of the animals is good. Far more sophisticated and complex models (e.g. Olynk and Wolf, 2007) generally produce the same overall outcome via use of sexed semen in a well-managed intensive operation makes sense.

Is there a genuine need for a new approach to sexing semen?

Despite all the arguments described previously many producers see cost, lower pregnancy rates, management issues etc as barriers to adoption of the technology. The current system is also somewhat inflexible. A producer has to buy semen from a commercial source and whilst this has advantages, such as superior genetics, it comes at a cost. In the beef industry where many producers use their own bulls, which they have bred selectively over a long time, or buy them for relatively modest cost from a bull breeder whose animals have performed well previously.

There is little chance they can have the semen of these animals sexed and even in the rare cases where it could be done either the semen or the bull has to be transported to the semen sexing machine. This can present severe logistical issues impossible to overcome. Development of a lower cost technology which did not require sophisticated technology and expensive equipment and which was not as wasting of sperm (only about 50% of the sperm present in a sample are recovered after sexing is complete) would significantly lower cost and if this technology were sufficiently flexible to be used on farm with the producer's bull and cows many of the producer reservations would disappear. Of course this would not obviate the sale by bull breeders of semen, either sex selected or not, from animals with superior genetics so ensuring genetic gain can still be captured.

What would a low cost technology for sex selection of semen look like?

A new method for sex selection based on the same physical parameter (i.e. difference between X and Y sperm in DNA content) seems difficult to envisage for a number of reasons. There is concern that any manipulation of the DNA opens the possibility of damage which could affect any resultant embryo, although there is no evidence in any species using the current method of staining DNA that this occurs, so the technical validity of this concern may not necessarily follow. The real question is whether other differences between X and Y sperm exist and can be exploited. As mentioned earlier a range of physical differences have been tried as a basis for separation and all have failed for various technical reasons. One technology which was used from the mid-1960s was electrophoresis (Sevinc, 1968). There are a number of published reports of the utility of this technology (e.g. Shirai *et al*, 1974, Shishito *et al*, 1975 and there are other examples) which never achieved commercial success. Electrophoresis is used to separate other cell types successfully. It relies on the existence of differences in surface charge on the cells to be separated. The surface charge of cells is generated mostly by the proteins and so these data have been interpreted to suggest the existence of differences in surface proteins between X and Y bearing sperm.

This is not a new concept and indeed it has provoked numerous studies characterising the sperm surface. This is because many of the biologically significant functions of sperm are mediated by components of the sperm surface. This is due to both the intense structural specialisation of the sperm cell and also its unique biochemistry. Once released from the seminiferous epithelium sperm cannot synthesise proteins and so the surface of the sperm can only be changed by interaction with components of its environment both in the male and female tracts. This can mean either modification of existing sperm proteins or the addition of proteins secreted into the sperm environment. The biological significance of the sperm surface has spawned many studies. Indeed it seems that the question is revisited every time there is a technological advance which can potentially yield more information. The latest of these technologies is proteomics. This technology provides exquisitely sensitive data and so the less abundant sperm proteins can be studied as well as the more abundant proteins previously charactised by other technologies. We now have sperm proteomes for the key rodent species (rat and mouse), for many of the commercially important farm animal species (cattle, sheep, pig, horse) and of course humans. The list grows rapidly. Indeed we mostly have multiple proteomes for each of these species. We have far fewer studies on X or Y separated sperm.

If a difference in surface protein(s) can be identified the idea would be to produce specific antisera to the unique protein(s). This antisera could then be bound to magnetic beads which could then be exposed to sperm from a normal ejaculate. The antisera would bind to the unique protein. A magnetic field would be applied so that those sperm bound by the antibody would be separated from the sperm which did not bind to the antisera. Subsequently the bound sperm could be released by chemical treatment and the beads recycled. The treatment could be repeated on the two separated sperm populations to increase the purity of the separation. If more than one protein differed between the surface of X and Y sperm then multiple antisera could also be used theoretically increasing the efficiency of the separation. Many other refinements to this procedure are possible. For example, if only one sperm population is required, say X sperm, it may be wisest to select with antisera directed against Y sperm repeatedly and the sperm attached to the beads discarded preventing any concern of damage to the desired sperm population by the separation process.

There are other advantages. Large amounts of antisera could readily be produced so the system could be scaled up if required. The separation technology is simple and does not require high levels of skill by the operator and the equipment is inexpensive in comparison to that currently used. It is also quite rapid and could certainly be faster than the current technology. All these factors would dramatically lower the cost of sexed semen. Importantly, there is potential to take this technology on farm thus obviating the current need for either the bull or at least his semen to be transported to the sorting machine. Used on farm, with good herd management the cows could be inseminated with fresh rather than frozen semen thus improving conception rates. A methodology such as that described would be expected to greatly enhance the use of sexed semen thus ensuring only animals required were generated with potential benefits for stocking rates, land management and the environment.

Where are we at present?

My colleagues and I have spent significant time developing the techniques required to investigate this question. Whilst many sperm proteomes have been published their complexity and usefulness is limited. We have spent time developing techniques that focus on the sperm surface proteins rather than the total sperm proteome. We have published (Byrne *et al*, 2012) the first sperm surface proteome. It contains 419 proteins in a mature bull sperm plasma membrane fraction. Protein domain enrichment analyses indicate that 67% of all the proteins identified may be membrane associated. A large number of the proteins identified are conserved between mammalian species and are reported to play key roles in sperm-egg communication, capacitation and fertility. The major functional pathways identified were related to protein catabolism (26S proteasome complex), chaperonin-containing TCP-1 (CCT) complex and fundamental metabolic processes such as glycolysis and energy production. We have also identified 118 predicted transmembrane proteins, some of which are implicated in cell adhesion, acrosomal exocytosis, vesicle transport and immunity and fertilisation events, while others have not been reported in mammalian LC-MS-derived sperm proteomes to date. We tested a number of these proteins by immunolocalisation for their unique presence on either X or Y bearing sperm but none showed specific localisation of this kind.

This study was undertaken as a prelude to studies of separated X and Y sperm. In itself it provides useful information about sperm function but it shows the significant complexity of the sperm surface. In addition it contains components present on both the external and internal surface of the sperm membrane. We needed to focus on the proteins on the external surface of the sperm plasma membrane as these would be accessible to the antisera. Several approaches were investigated and deemed unsatisfactory for various reasons. Finally a technique previously used with bacteria was utilized.

This technique is referred to as “cell shaving”. The cells are lightly treated with trypsin and the resultant peptides collected and subjected to proteomic analysis. Over 100 proteins were identified using this highly specific and very sensitive technique. These were in generally not highly abundant proteins and it was therein lay the problem. The best separation of X and Y sperm in bovine is 90% of the desired sex and 10% of the sex not required. This is a consequence of the procedure ulitised. When we sought to apply this method to X and Y sperm fractions the 10% contamination by the undesired sperm made identification of proteins confined to either X or Y sperm difficult.

The contamination meant identification of a protein present only on either X or Y was impossible. If contamination was 10% theoretically it would be expected that such a protein would be 9 fold enriched in the desired population. While enrichment of some proteins was detected none approached 9 fold. The sensitivity of the technology was defeated by inability to produce sperm populations of sufficient purity.

Other approaches including immunological tolerisation experiments may assist in overcoming these issues and are being assessed in collaboration with Monash University.

Conclusion

The current technology for separation of X and Y bearing sperm is serving the industry well and producing commercial benefit but it would seem that if the potential of sexed semen is to be fully realized a cheaper, simpler, more robust technology is required. Proteomics has so far not helped in the search for the Holy Grail but this approach has yet to be fully tested.

Acknowledgements

I wish to thank my colleagues Tamara Leahy my former post-doctoral fellow who worked the last several years on the Dairy CRC sperm surface proteome project and our CSIRO collaborators Michelle Colgrave and Keren Byrne for their proteomic expertise, research contributions, advice and general discussions.

References

Garner, D.L and Seidel Jr., G.E (2008) Theriogenology 69: 886–895 History of commercializing sexed semen for cattle

Moruzzi JF. (1979) J Reprod Fertil 57:319–23. Selecting a mammalian species for the determination of X- and Y-chromosome-bearing sperm.

Olynk, NJ and Wolf, CA (2007) J. Dairy Sci. 90:2569–2576 Expected Net Present Value of Pure and Mixed Sexed Semen Artificial Insemination Strategies in Dairy Heifers

Garner, DL, Evans, KM and Seidel, GE (2013) Methods Mol Biol. 927:279-95 Sex-sorting sperm using flow cytometry/cell sorting.

Pinkel D, Lake S, Gledhill BL, Van Dilla MA, Stephenson D, Watchmaker G. (1982) Cytometry 3:1–9. High resolution DNA content measurements of mammalian sperm.

Garner DL, Gledhill BL, Pinkel D, Lake S, Stephenson D, Van Dilla MA, and Johnson LA (1983) Biol Reprod 28:312–21 Quantification of the X- and Y-chromosome bearing sperm of domestic animals by flow cytometry.

Johnson LA, Flook JP, Look MV. (1987) Gamete Res 17:203–12. Flow cytometry of X and Y chromosome-bearing sperm for DNA using an improved preparation method and staining with Hoechst 33342.

Johnson LA, Flook JP, Hawk HW.(1989) . Biol Reprod 41:199–203. Sex preselection in rabbits: live births from X and Y sperm separated by DNA and cell sorting.

Sevinç, A. (1968) J Reprod Fertil.;16(1):7-14 Experiments on sex control by electrophoretic separation of spermatozoa in the rabbit.

Shirai M, Matsuda S, Mitsukawa S (1974) Tohoku J Exp Med. 113(3):273-81 Electrophoretic separation of X- and Y-chromosome-bearing sperm in human semen.

Shishito S, Shirai M, Sasaki K. (1975) Int J Fertil. 20(1):13-6. Galvanic separation of X- and Y-bearing human spermatozoa.

Byrne K, Leahy T, McCulloch R, Colgrave M L, Holland MK. (2012) Proteomics12(23-24):3559-79 Comprehensive mapping of the bull sperm surface proteome.

TAKING TECHNOLOGY TO NEW HEIGHTS

Mark Billing

Dairy Farmer, Colac Vic

Our farm is 5km west of Colac in the South West of Victoria. Together with my wife Sam we operate a 500 cow dry land pasture based operation which uses mainly grain as our off farm input to manage pasture shortfalls. Our autumn calving pattern follows our pasture growth curve which can be a challenge given our average rainfall of 600ml.

Technology has played a large part in our operation over many years and the challenge has always been finding the right fit to assist with on farm decisions and managing farm resources whether that is the animals or inputs.

Whilst we may not be taking technologies to new heights, we are applying it practically on farm and using it to drive profitability. The opportunities for technology to measure and manage farm inputs are very real but the rigour around this needs to be applied in the same way as any other purchase, I believe the following needs to be considered:

- **Ease of use**
- **Relevance to our farming system**
- **Cost and time effectiveness**

Ease of use

If the technology is difficult for you or staff to use and/or understand then the usefulness of the product will be limited no matter how good it is. It is important that where possible a central user interface should be used as a collection and decision making point.

Relevance to the farming system

Many products are developed overseas and may not have a relevance to the farming system to which it is being applied here. However there may be an opportunity to modify or adapt to a local system with some lateral thinking.

Cost and time effectiveness

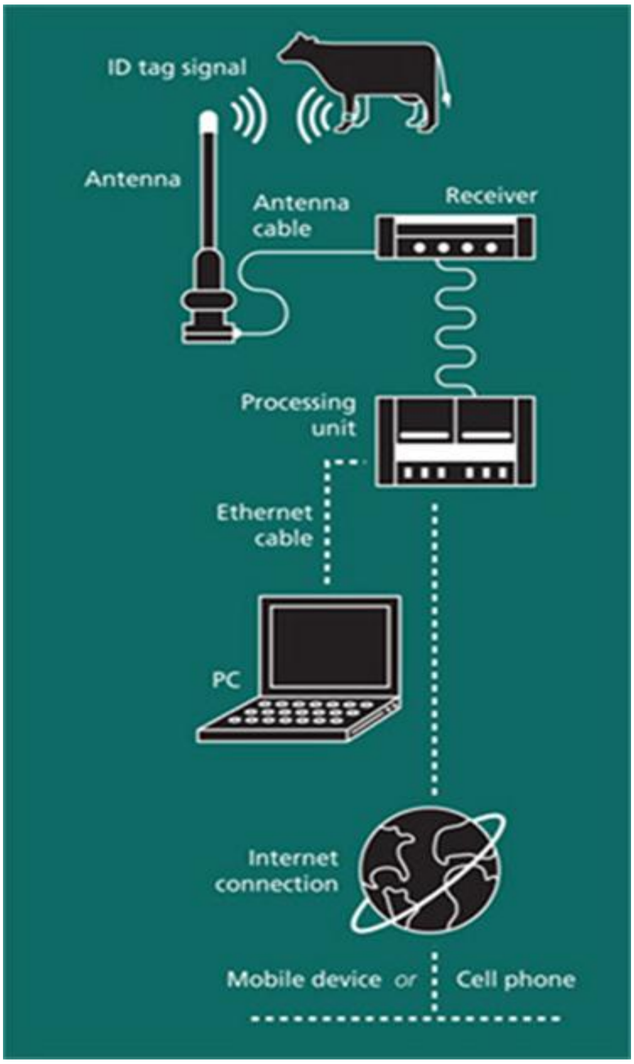
Technology can provide a lot of information to help with day to day decisions, although if this information is not acted, on or presented in a usable way a lot of time and money can be wasted. I believe that any technology you implement needs to assist with the delivery of good and timely decision making, e.g. production based grain feeding enables you to set a grain diet based on desired outcomes then deliver grain at an individual or group based level.

Technologies we are utilizing on farm

- Milk metering with conductivity
- Individual production and body weight grain feeding
- Walkover scales
- Cow activity
- Automatic drafting
- In shed alerts and individual cow information

In our business all of these technologies are interlinked in order to complement each other. For example our walkover scales are linked to our grain feeding; the milk metering is linked to the grain feeding; the conductivity and activity is linked to the automatic drafting and all of these functions can be accessed in either the office or cow side level.

It is important that with whatever system you are using it needs to be easily accessed and understood but also it must be powerful enough to assist with the decision making and delivery of desired outcomes.



What's next?

As I write this, we are installing equipment on a trial basis to track cow activity in real time (Cow Scout). With this technology we are hoping to have real time alerts delivered to smart phones and also link in with our other systems.

This is a good example of a technology that has been developed for barn based farming but we are exploring the possibilities of using it for pasture based farming and having the usefulness of real time data on cow activity.

We are also installing a grain monitoring system which will enable us and our feed company to monitor grain usage rates and silo levels on a daily basis.

This will enable the grain company to pre-emptively order grain based on how fast it is being used and how much is left in the silo. We envisage that this will lead to SMS and/or emails being automatically generated to place orders. This system will be accessed as an internet based interface.

Conclusion

The ability of technology to assist farming operations is increasing rapidly. The amount of different systems that are available now make it difficult to decide upon the best one for a given farming system. It is important to ensure that there is good backup and training available for the technology you wish to employ. We have seen significant benefit from being able to manage and measure cow's behavior and production on an individual level, and will continue to explore new ways of including technology in our business.

SHOULD ANYONE BUILD A NEW DAIRY WITH A ROBOT?

Kendra Kerrisk

University of Sydney, Camden NSW 2570

Robotic milking has been commercially available now for more than 20 years. The first installation in Australia was commissioned 13 years ago. It is fair to say that adoption of robots in Australia has been a slow and cautious journey. To be fair that is exactly what it should have been. We all know that the technology was developed for the small indoor herds that are so common throughout many European countries.

Understanding whether it had a place in our expansive, larger pasture based operations in Australia has been imperative as we know that one of the key causes for technology failure on farm is a direct result of inaccurate expectations.

It has been important to ensure that farmers are well positioned to make informed and knowledgeable decisions with the right expectations. As an industry the key things that we needed to be sure of was that cows could milk themselves with sufficient regularity to achieve the targeted milk production levels and that pasture utilisation would not be compromised.

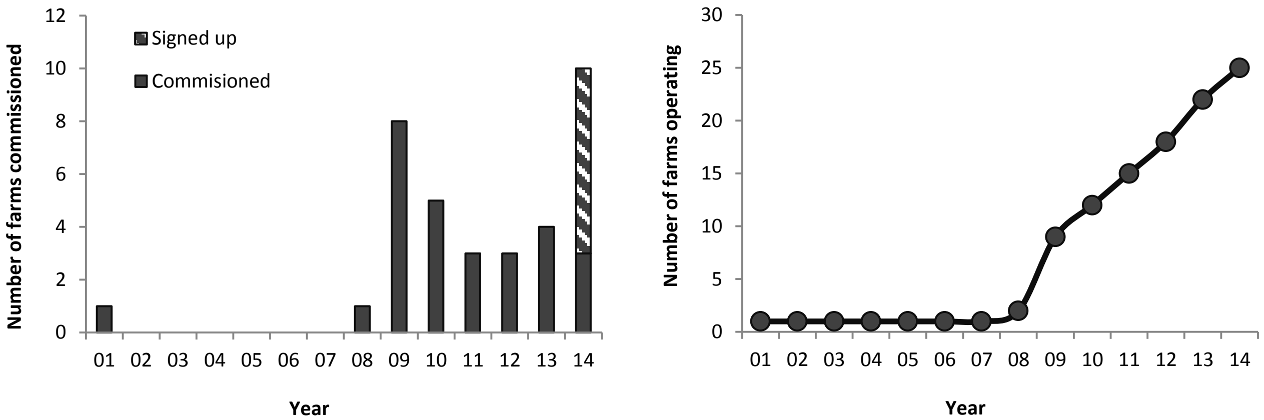


Figure 1. Rate of adoption of robotic milking units in Australia from 2001 to mid-2014

Australian Robotic Milking adoption rates

Figure 1 shows the number of farms commissioned per year and the cumulative number of farms operating each year (taking into account three installations that have ceased operation). The adoption trends in Australia are very similar to those seen overseas (Figure 2) with an initial adoption rate that drops off after a year or two and then takes a few years to start increasing with an exponential adoption rate after about 5 years. We believe that Australia is following the same trend.

It takes a resilient personality to have taken the courage to be one of the early adopters and it is these farmers that have paved the way for our future generations with regard to milk harvesting options. These early adopters have been courageous enough to take the plunge and generous enough to share their stories at conferences, field days, discussion groups and through the media.

It has been a tough journey for some of them as they have struggled with the scrutinising eyes of their neighbours and peers whilst trying to adapt to a new way of farming. They have often felt that everyone that is waiting for them to fail in their new venture. Nevertheless, the vast majority of them have succeeded and willingly declare that they made the right decision for them in their business.

As an industry we have learnt a lot from these farmers which are helping us to give new adopters the best chance of being successful with their operations.

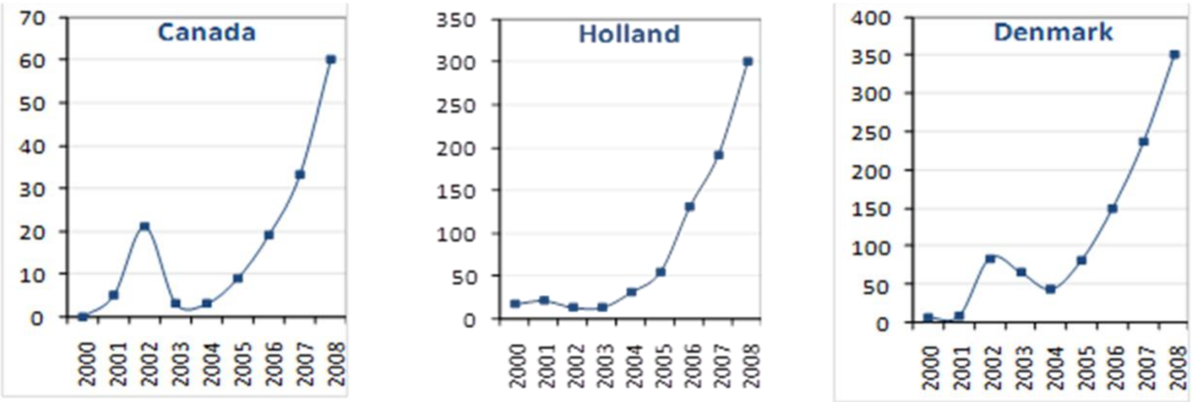


Figure 2. Early adoption trends (number of farms commissioning per year) for Canada, Holland and Denmark.

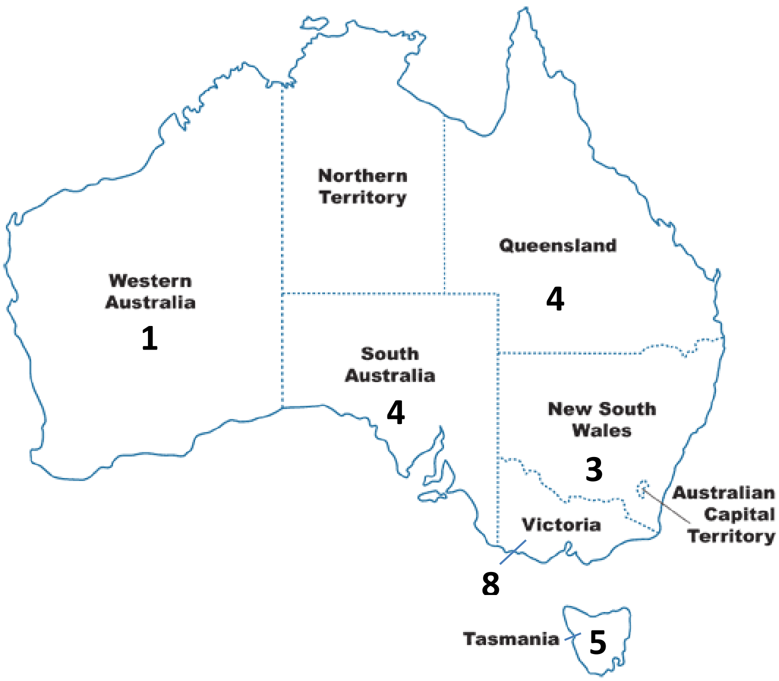


Figure 3. Number of Robotic Milking farms operating in each state of Australia

Proving the concept that robotic milking is a viable option for Australian pasture-based farmers has been important but now the farmers are the proof. As an industry we continue to develop our knowledge and understanding around the management of a robotic milking farm. We are always keen to learn how we can refine the operations to improve the productivity whilst ensuring that animal wellbeing and farmer lifestyles are enhanced.

The two biggest areas for attention at this stage of the robotic milking journey are to understand the potential or limitations to managing voluntary cow traffic (particularly in a pasture based system) for large herds and to increase awareness of the technology so that a larger pool of people make the right decision (either to adopt or not to adopt) about the adoption of robots on their farms.

At the time of writing we believe that the largest operations in the world that fit these two categories (voluntary milking and pasture-based) are Camelot dairy in NZ with 9 single box robots and around 600 cows and Gala farm with 550 cows and a robotic rotary.

We are fortunate enough to have both of those farms represented on the 2014 DRF Symposium Program. But if our industry is to continue to grow (through size and number of farms) the number of farms that are larger than 600 cows will also continue to increase. It is important that we understand the suitability (or lack of) of the robotic milking technology for these farms.

You don’t know what you don’t know – increasing awareness

Building awareness about the potential impacts of robotic milking on the business is best done by sharing the stories of the successful farmers who are already capturing the benefits. There are 25 robotic milking farmers and 25 unique stories that go with that. Let’s look at some examples of how robotic milking has helped to grow the individual business and thereby contributed to the growth of the industry:

1. Robotic milking was the technology that made entry into the dairy industry (through conversion of a dry stock farm) an appealing option for one farming family. They never wanted to milk cows but the appeal of a regular milk cheque and automated milk harvesting equipment gave them the incentive to convert. So there is a possibility to grow the dairy industry through similar conversions. There must be other farmers in Australia that fit the same mould.

2. Robotic milking was an option considered for a farming family to grow their production per cow. They wanted to shift their hours spent on milk harvesting to managing the operation in the hope that they would produce and utilise more home grown feed, get improved reproductive performance, reduced animal health costs and increased production by milking early lactation cows more often. They were not looking to improve lifestyle; they wanted to work smarter not less.

3. When realisation hit that the existing dairy was too small and too old to continue to operate effectively robotic milking was considered along with other options including exiting the industry. In the later stages of a dairying career it can be challenging to justify such a large investment as a new dairy but if it creates the opportunity to stay in the industry for another 15 years then its appeal is likely to increase.

4. With a need to 'move over' and make room for the next generation, a robotic installation at the far end of the farm with the expectation of future expansion by acquiring a neighbouring property was a viable option for another farming family. It gave an opportunity to allow the next generation to get into the industry without forcing another generation out.

5. Health concerns which limited the ability to continue with the physical demands of milking forced one farmer to consider robots as an alternative to exiting the industry. Reducing the amount of employed labour and scaling back the operation created a work load and routine that was manageable.

6. For many people, managing one dairy operation is sufficient but a future-proofing exercise that led to the conversion of a run-off block has resulted in a significant increase to the amount of milk harvested for a young farming couple. Commitment and focus to implementation of efficient routines and management practices have allowed this family to manage both the conventional dairy and the robotic dairy without increasing the pool of labour.

This is just a snippet of 6 of the unique stories but you start to get a feel for some of the circumstances that created a need to investigate the 'fit' for robotic milking into the existing farming operation. Even if you have a perfectly good dairy there may be a way that you could viably grow your business with robotic milking.

The decision making process

If you are in position to start considering robotic milking and its' fit for your operation, it is important that you do your homework. Consider the various brands and types of robotic milking equipment that are available. If the opportunity exists, talk to other farmers in your region that have the different brands and determine their level of satisfaction with technical support. Consider if there is anything significant you wish to change about your farming system – if you are changing your dairy it might be an effective time to also build the feedpad that you have been planning for the past 5 years. You should not change your farming principles because of the robotics but it might be an opportune time to assess what you do and when/how and whether it is still the right approach for things like your region, milk contract opportunities, and regional feed availability and pricing.

Work your way through the FutureDairy Partial Budget Calculator which can be found at: http://www.futuredairy.com.au/media/FD_Partial_Budget_Calculator_4.pdf. This will help you to work through what costs and income are likely to increase or decrease. The calculator takes you through each item and explains why you might expect an increase or decrease to position you to make the most accurate predictions for your operation. The numbers you generate can then be taken to a financial advisor. Financial stress is another key factor contributing to failed adoptions – ensure that your budget is conservative and viable.

If you make the decision not to invest in robotic milking on the basis of your unique options and circumstances that is fine. Accept the fact that this is a viable option for some but not others. Support and encourage peers who decide to invest in the technology just as they would encourage you if you decided to invest in a new rotary.

If you decide to invest in robotic milking, ensure that you develop a network of support. Build relationships with existing robotic milking farmers, get to know the experts that are providing support to farmers in your region, introduce yourself to members of the FutureDairy team and the Development Officer for robotic milking systems – Nicolas Lyons. Make sure you are receiving the industry newsletters on robotic milking and that you are on the mailing list for events put on for robotic milking farmers. All of these mechanisms will help to increase your knowledge and your whole farm performance thereby reducing any negative impacts of the adaptation period and increasing the potential for you to harness all the benefits of robotic milking.

Above all: remember that management makes milk, robots only harvest it.

The installation of robots requires a hefty level of commitment and dedication; it may take a full 12 months for you to start to really capture the benefits of the technology. During that time make sure that you do not take on too many other 'projects'. If you have other arms to your enterprise, consider how you can minimise the need for you attention on those to ensure that you can remain focussed on the robotic operation. Data management and computer based monitoring are imperative to a successful operation. If these are aspects of your current operation that you delegate then are likely to struggle to achieve efficient and effective management routines.

NSW Dairy Farmers, where can you find the best online resources for all your dairy farming needs?

Dairy NSW coordinates the dairy services levy for the NSW Dairy industry through the support and coordination of research, development, education and extension activities.

www.dairynsw.com.au offers regular updates of relevant information for NSW dairy farmers.

Home page

- Current extension activities
- Upcoming NCDEA education opportunities
- Member information
- Take it to Elsie – research expertise to improve farm systems

News and events

- Copies of quarterly and weekly news *The Milk Flow* and *The Snapshot*
- Dairy facts
- Event Calendar
- Media Releases

Regional dairy groups

Five Regional Dairy Groups (RDGs) operate within the Dairy NSW region conducting activities relevant to the dairy industry in their individual regions.

Contact Dairy NSW

Roxanne Cooley
Executive Officer
T: 0412 825 466
Email: info@dairynsw.com.au

ROBOTS CONVERT RUN OFF BLOCK INTO A PROFITABLE DAIRY

Marcus Crowden

Dairy Farmer
Caveside, Tasmania

The installation of robotic milking units enabled the Crowden family to convert a run off block into a highly profitable dairy farm. The 80ha property (50ha milking area) supports 205 spring-calving milkers, with the plan to increase to 240 cows next season. The operation involves less than a full time labour equivalent (0.75 FTE). The family believes the key to the system running smoothly is the integrated herd management software which operates the robots, out of parlour feeders and cow traffic.

Marcus Crowden and his wife Zed, dairy with his parents Denis and Sheryl, operating two properties at Caveside near Launceston, Tasmania. When their home farm reached its milking capacity they looked at options for expansion.

“The run off block is 5km away from the home farm, so automatic milking was a profitable way for us to increase our milking herd without buying more land or employing more staff. It allowed us to increase the combined herd from 320 to 450 (and 500 cows next year) and total milk production from 2.4 to 3.2 million litres.

In mid-2012 the Crowdens initially installed two DeLaval VMS robots and three out of parlour feeders but within a year added another robot and three more out of parlour feeders to increase the herd size.

“We were pleasantly surprised at how quickly we adapted to the new system. We expected it to take a full season to get used to the 3-way grazing, working out a routine and learning the hardware and software associated with the robots. But after just four months, our system was running smoothly and we were enjoying the benefits of automated milking,” Marcus said.

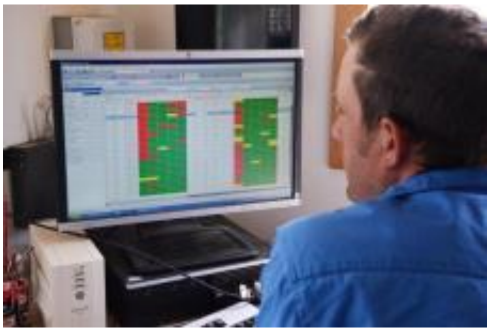
A key to its success for the Crowdens has been the ability to manage much of the operation remotely, through the computer at home, or a mobile phone.

“We can see what’s happening through two web cams located at the dairy. And we have remote control of the robots, smart gates and feeding system through Delpro, the herd management system that came with the robots. So even if we are in Melbourne on holiday we can keep track of what’s happening and sort out most issues that arise. We really enjoy that flexibility.”

Marcus is pragmatic about the amount of time he spends on the computer.

“DelPro records an enormous amount of data and there’s a wide variety of report options. You could spend 10 hours a day on the computer if you wanted to; but it wouldn’t necessarily make you more money. I spend about 15 minutes a day reviewing reports on production, milking frequency and feed intake. And about once a week I’ll spend about an hour looking at records in more detail,” he said.

All of the herd data is recoded in Delpro so all the records are in the one place and easily accessible.



“Every time a cow does something, it is recorded. Nearly all of it is automatic. The main data we enter manually is heat detection, inseminations and health treatments such as antibiotics for mastitis. The only one that takes time is the inseminations; I generally record that in a notebook and enter it into the computer on a rainy day.”

On weekdays Marcus spends 2-3 hours at the robotic farm, but prefers to work longer on Friday and Monday to allow him to have most of the weekend off.

“When I’m playing football, I can organise it so that I only need to spend 15 or 20 minutes a day at the farm on the weekends.

Marcus has been particularly pleased with the out of parlour feeders which enable individual feeding.

“We installed them primarily to encourage cow flow – so the cows had a reason to want to leave the robots after milking. Individual feeding means we are getting much better value for our investment in concentrates by directing more feed to the higher producing cows.”

Initially Marcus let Delpro determine the feeding level for individual cows but once he gained confidence he adjusted individual feeding levels according to his own specifications.

“DelPro is really user-friendly. And I liked the way we could run with the system settings in the early days but have the flexibility to customise settings to our own needs if we want,” Marcus said.

With such a high stocking rate (currently 4.25 cows/ha and expected to reach 5 cows/ha next year), Marcus keeps a close eye on production per hectare. Now in its second season, Marcus is aiming to produce 2000kg milk solids per hectare. While cows are fed an average of 2-2½ tonnes concentrates per lactation, Marcus is also aiming for very high pasture utilisation: 20 tonnes/ha.

“We have to get our pasture allocation right to maintain voluntary cow movement around the system. It isn’t as hard as I expected. But

I am also keen to achieve high pasture utilisation because it has so much impact on our profitability."

The number of cows visiting the robots is relatively even throughout the day and night, although surprisingly, the busiest time of day for the robots is between midnight and 4am.

In pasture-based automatic milking systems, this is often a period when few cows present to the dairy to be milked. This is because pasture-fed cows typically rest from about 2am to about 5am following a grazing session around midnight.

Marcus has programmed his system allow access to fresh feed four times a day as follows:

1:40am-8:30am:	45% of daily pasture allocation
8:30am-4:30am:	35% of daily pasture allocation
4:30pm-11:00pm:	20% of daily pasture allocation
11pm-1:40am:	feedpad (brewers grain or silage)

At the peak of lactation Marcus aims for cows to be milked three times a day on average, although the higher producing cows will be milked as often as four times a day.

"For example, in November we had a cow producing 70-80L/day and she was being milked 3.6 times a day."

The FutureDairy team recently analysed the labour efficiency on the Crowden's robotic farm. They estimate that the Crowdens have 0.75 labour units for 205 cows, which is equivalent to 270 cows per full time equivalent (FTE), more than double the Tasmanian average of 100 cows per FTE and well above the average of the top 25% (137 cows/FTE).

DeLaval AMS systems specialist, Anthony Baxter, said the Crowdens have the best performing AMS set up that he has seen in Australia.

"They have an amazing ability with DelPro software. They picked it up very easily and use it to run their farm remotely – so the system works for them rather than them working for the system," Mr. Baxter said.

The irony is that Marcus still milks cows on the home farm.

"We'll be ready for a new dairy on the home farm in 5-8 years and robots will be the first option we look at," Marcus said.

CAMELOT
'WHERE MAGIC HAPPENS'

Frances Beeston

Dairy Farmer
Anama, New Zealand

A bit about me…...

I believe my love for farming is part of me – a healthy combination of my Mum and Dad – Mum loves her cows and is extremely passionate about her cow families and breeding. Dad is the business and opportunity finder, who often "swims against the tide".

My roles have varied from dairy assistant to now running my own 9 Lely robotic milking farm in Anama, an hour and a half from Christchurch. A farm called Camelot – 'where magic happens'.

To compliment my practical knowledge and experience I completed a Diploma in Agribusiness Management, I also spent time in America training in Embryo Transfer.I have been fortunate enough to have travelled to Africa, Europe & USA. I have worked on properties in Sweden, and in Canada where they were heavily involved with showing cows and breeding bulls.

I have been involved in the Young Farmers organisation for many years. For me, becoming a robotic farmer isn't just about milking the cows differently. I have become a tour guide, this is something I do for free – I call it my community service. I talk and educate people about what I do, why I do it and how whilst showing best practice in our farming operation and the environment.

Camelot - a bit about the operation……

I am in partnership with my parents Bryan and Annette on 260ha. Camelot is a pasture-based robotic milking system, milking 580-620 Holstein Friesian and Brown Swiss cows, through 9 Lely A4 Astronauts, We milk year around and have been operating for nearly 2 years. They say the past moulds who you are today – my family started farming in the North Island in Northland, where Dad and Mum milked 300 cows. As time passed they have progressed through the dairy industry, which in New Zealand has a pretty good path for doing this. In 1995 they moved to Canterbury and share milked with Tasman Agriculture (Corporate Dairy Farm owners). When we moved to Canterbury I was 9.

My Parents were pedigree breeders so for me this was nothing new, I have always loved animals, and am passionate about making sure they are fully fed and healthy to their full potential. We have always bred cows for high production, high protein, good udders and sound confirmation.

When we starting feeding and growing the cows better, production increased and we then needed to look at our dairy business and how we managed it:

- How we harvested the milk
- The calving patterns
- Empty rates
- Winter milking
- Individual feeding

We took the decision to change to winter milking and got a contract for a premium price for town milk. Due to the increase in production out empty rate increased so we changed to Autumn calving which helped support the contracted winter milk volumes. We added individual feeding to drive the cows more, with stage of lactation and production.

We started milking 3 times a day milking in the peak of lactation on one farm for 10 weeks with the objective of both gaining production and the overall benefit to cow health. We found this wasn't people friendly as the shed was running for over 12 hours a day, and it's a whole different mind-set for farming staff to get their head around. There are very few farmers in NZ who milk 3 times a day.

This lead us to look at robotics - in NZ and Australia, barns vs. grazing, Lely or DeLaval…...

At first we were set on DeLaval, then changed to Lely, and at the end of the day it came down price, long term warranty and the service contract.

We decided on robots with a grazing system – I was set in my way about this, whoops. I spent three weeks working in a barn the bugs in barns concerned me - I saw cows get mastitis and E.coli and how it can nearly kill a cow so quickly, it scared me a little. Barns in Canterbury we very unheard of and I was uncomfortable with our lack of knowledge and experience with barns.

We wanted size and scale with the robots - to help dilute the costs. The farm is 245 ha effective - so 8 robots and 500-550 cows seemed ideal, allowing it to help support itself with Winterfeed, Growing Silage and some young stock and drys kept on the property. Space was allowed for an additional robot which was commissioned in January 2014 (taking us to 9 single boxes).

As this was a green field site, we started fresh; building, robotic dairy shed, installing 8 Lely robots, vet area, effluent system, 500-cow feed pad, silage bunkers, implement shed, races, water troughs system, irrigation system and pivots, fencing, staff accommodation etc.

With having robots we wanted to milk all year around and keep the system full - for us this means calving 4 times a year. Ideally I should have cows calving every day, but it's easier to manage calving for a month every quarter - February, May, August and November.

We have 4-way grazing (A, B, C, D) plus the feed pad - this means every 6 hours the gates change to a new destination, this is a reward system, so when the cows come in they have access to the feed pad for supplement, grain in the robots, then after milking they go to a fresh break. It's important to keep total feed quantity across the four blocks balanced. In the Winter this becomes breaks of Kale instead of grass.

Pasture management is crucial to encourage movement between breaks, so it's critical to accurately measure what's in the paddock. In the summer months this means topping in front of the cows, or dropping paddocks out for silage. If there are too many cows left in the paddock then I ask why - too much feed, weather, walking distance, irrigation, distracted by other animals (particularly drys and calves), break down or back log in the shed? It's about having a constant flow of cows coming and going 24 hours a day.

My cows do a lot of walking (3-6 km a day) so they are fit and healthy, but they do it by choice, usually single file at their own speed. I do lose milk production for the excess walking , but that it something I live with, I accept a lower average milking frequency (average 2 milkings per day compared to 2.3-2.4) as more milkings would mean even more walking.

It takes time to learn about the robots - they are not the 'be all and end all' - they are a tool. They are machines that operate 24/7 so they require daily cleaning and maintenance to keep them going. When I run the system close to capacity all the time, I can't afford any breakdowns. It takes about 1-1.5 hours a day to carry out the routines tasks around the dairy - cleaning, servicing, filling chemical containers, cleaning calf buckets etc.

Picking the right cows is important. I have trained over 750 cows to the robots now. Initially I chose cow families, cows that looked nice, good udders, good teat placement etc. but I have come to learn that in a grazing system I want leader cows. So now if I need any cows, I look for the first round on the rotary, there are usually the cows waiting at the gate to be milked, so they are self-motived to move and they respond well to the grain and rewards of the robot system.

A team of 4 and myself work at Camelot – the team are the most important aspect of the operation - I couldn't do it without them. It takes time to get the right balance, the right team dynamics to get it all to work. It takes a different type of person to work with the pasture-based robotic system – people that are open minded. Then it's about retaining them – this is a challenge as good staff want to progress into share milking and farm ownership.

What I do and why I farm is different, it's not right or wrong, just different. It's what I like and what I believe. When farming with robots there is an interest from people, schools and groups to come and see the operation, I talk to them about what I do and why.

The first year was hard, a lot of learning for me, the staff and for the cows. It is a new farm and it's still developing. The second year is good, the cows know the system, they are calving down as experienced animals and they know what to do. The third year should be great!

Summary

If I was to do it all again on a green field site - I would just build a barn. It would be cheaper than the entire infrastructure surrounding the shed and farm. But If I was using upgrading an existing Dairy Farm I would go for a grazing system. In an ideal world, I would like a 'Hybrid System' as I see milk losses in early lactation through excessive walking distances, weather, and grass variability. On the other hand, in barns I see fitness, feet issues and fat cows in late lactation as issues.

Going forward I would like to be able to speak at more events such as this, do more ET work, continue to develop my property and fine tune its inputs/outputs, travel some more and spend time with my family and friends.

THE FUTURE OF RURAL EDUCATION

Cameron Archer AM

Principal
Tocal College, Paterson
cameron.archer@dpi.nsw.gov.au
0427 202 948

Good morning….

I am very pleased to have the opportunity to speak to you today about rural education and its future. I have spent my career working in this area and in fact much of it in association with the dairy industry which includes the establishment a dairy apprenticeship in the Hunter through Tocal many years ago.

Unfortunately the community sees the dairy industry largely in retreat in other words they think there are less and less farms and that means there is less and less industry. That is far from the case but that is a community perception.

The theme of this year's symposium is growth through science and innovation – I suggest science and innovation are not enough

I was recently referred to a paper given at the Outlook conference in Canberra by Professor Ross Kingwell of the University of Western Australia[1]. Ten years of research in Western Australia proved, I mean proved, that training was a key factor in agricultural productivity. This is not a dream; this is a fact from a decade's research by some of the best brains in the country. It also said that the most profitable farms innovated and adopted innovation which is no surprise.

I watched the replay of that paper on the internet and after the speaker closed the speaking the Chair of the conference session rose and said

"Good to see that everyone is saying we should invest more in R&D".

The subsequent questions and answers following the paper were largely focused on research and development and not training.

Here in lies the problem.

We seem to be very focused on research and development but seem to have a struggle with having the results of that research adopted through innovation and into farm practice.

[1] Nazrul Islam, Vilaphonh Xayavong and Ross Kingwell (2014) Broadacre farm productivity and profitability in south-western Australia Australian Journal of Agricultural and Resource Economics, 58, pp. 1–24
The results of this research were presented at the 2014 ABARES Outlook Conference by Ross Kingwell

As an educator I see thousands of producers dollars spent on research but fewer dollars spent on education and training. In addition I see each industry doing their own thing, and also working as silos often in a competitive way within the policy space in Canberra. As a result I believe the bureaucracy and funders divide and rule our rural industries because our industries are not united; instead they are internally competitive.

Despite these challenges we continue along and some educational institutions have prospered and others have not. Fortunately Tocal has been able to prosper due to the great support it has had both from rural industry and also NSW DPI. Other colleges have been much less fortunate.

I believe the future of rural education is strong and is an absolute necessity for us to promote greater learning about the production of food and fibre.

Firstly - the schools sector…..

I have been involved in the establishment of an organisation called The Primary Industries Education Foundation to encourage greater learning about food and fibre production in Australian schools. This has been quite successful but again, has not had the full support of all rural industries. Some have been strong supporters and on that we have been able to build a valuable profile.

Research shows that the earlier children learn about something in their school career the greater chance you have of building on that into the future.

There are about:

- Three million children at school in Australia,
- Taught by around two hundred and fifty thousand teachers in
- Nine thousand schools

Agriculture needs to ask the question as to whether it feels those students should know something about food and fibre production. When you do ask it the question is usually ‘yes’ when you then ask who should do it and how it should be paid for the answers are not so clear.

Firstly you must influence the national curriculum; we (Primary Industries Education Foundation) have been able to do that successfully. When the Foundation first started there was more reference to medieval agriculture in the school curriculum than there was anything to do with production agriculture. Fortunately we have been able to work with the national curriculum bodies and improve the situation.

We now need to encourage teachers to take on those curriculum topics and teach them and that is where we are at the moment.

The reason for having greater learning about food and fibre production in schools is twofold.

One is to have a community that understands food and fibre production and that means we maintain a social licence to produce and secondly by having a greater knowledge in the community about these matters we will hopefully continue to attract people to work in our industries.

If we do not – who is going to run the farm?

That leads onto work force development and the provision of people to run and service our rural industries including a steady supply of scientists for research.

We need people at all levels in our rural industries and fortunately over the years we have had a steady supply of young people undertaking traineeships, apprenticeships and full time courses at Tocal.

We have to work very hard to maintain this level of interest, fortunately we have had activities such as Cows Create Careers to assist us and I am pleased to take this opportunity to acknowledge those farms and people who acted as advisors in the local area who have supported this program in association with Dairy Australia.

Hunter River High School Farmer: Ross & Darren Wilson Advisor: Greg Duncan (Zoetis)	Tomaree High School F: Tom Wilson A: Kathrine Colaci (Lion)	Newcastle High School F: Matt Hogan,Tocal A: Michael Ison (Tocal)
Singleton High School F: Max, Cheryl & Maxene Moore A: Lindsay Moxey (Elders)	Cessnock High School F: John Redgrove A: James Hooke (Tocal)	Francis Greenway High School F: Brad Richardson A: Ewin Lewis (Consultant)
Rutherford Technology High School F: Graham Berry A: David Ninness (Semex)	Morisset High School. F: Terry Lambkin A: Michael Ison (Tocal)	Dungog High School F: David Williams A: Digby Rayward (LLS)
Mount View High School F: Max Wake A: James Hooke (Tocal)		

Secondly the post school sector - If we are to grow dairy production and not just maintain it, we have to ask how we do that.

I understand at present there are:

- 727 dairy farms in NSW
- milking a total of 200,000 cows
- average herd size around 250 – 300.
- staff cow ratio of about 1 – 80 to 1 – 100
- about 2,500 people working every day directly on farms.

Assuming a 40 year life cycle we need at least 60 new people per annum the churn rate is much higher than that so we need more coming through.

I also should say there are a lot of people who are absolutely committed to the dairy industry and will stay for 40 years.

If a contract was available for say 60c/litre plus CPI for the next 5 years for all the milk you could produce what would be your response?

You would need:

- More cows
- Upgraded facilities
- But you would probably need more people.

The question is where they would come from and what would their skills be.

We therefore need to work on many fronts in rural education, in the schools, in the community, in colleges such as Tocal in universities and so on.

I urge you not to take the next generation for granted – they have many options.

Let us make sure agriculture is an attractive one!

Especially……….. if we want growth in the dairy industry through science and innovation

Thank you

JAY•LOR®
Introducing the
5000 SERIES JAYLOR MIXER RANGE
PROUDY SPONSORING THE DRF EMERGING SCIENTISTS PROGRAM 2014
Single and twin auger mixers from 10m³ to 36m³
JAY•LOR®
BECAUSE NUTRITION MATTERS.®
5650
BECAUSE NUTRITION MATTERS.®
Standard Features
• Unique Patented Square-cut auger with patented sloped top*
• Tungston Carbide coated knives
• Patented adjustable discharge height HDPE/ Galvanized Conveyor
• Rapid discharge door
• Heavy duty planetary gearbox
• All welded mixing chamber
• Epoxy urethane paint
• Computer engineered undercarriage
• Heavy duty axles, hubs & spindles
5350
10-12m³
5425
13-15.3m³
5750
18.5-22m³
5850HD
22.7-27.2m³
HOWARD
199 Australis Drive, Derrimut VIC 3030
P. 02 8824 1900 F. 02 9674 6263
www.howard-australia.com
E. info@howard-australia.com
A Division of PFG Australia Pty Ltd. ABN 820 9303 7533
Contact Philip Myers on 0417319321
for further details

EFFECT OF RANKING FOR RESIDUAL FEED INTAKE ON RUMINAL METHANE EMISSIONS FROM HEIFERS

R.P. McDonnell[AE], K.J.Hart[B], T.M. Boland[C], A.K. Kelly[C] M. McGee[D] and D.A Kenny[D].

[A]Department of Agriculture and Food, Western Australia, 1 Verschuer Place, Bunbury W.A. 6230
[B]Animal Science Research Centre, Harper Adams University College, Newport, Shropshire, TF10 8NB, UK
[C]School of Agriculture, Food Science and Veterinary Medicine, UCD, Belfield, Dublin 4, Ireland
[D]Teagasc, Grange Beef Research Centre, Dunsany, Co. Meath, Ireland
[E]Corresponding author. Email: Ruairi.mcdonnell@agric.wa.gov.au

Abstract

Enteric Methane (CH_4) emissions from ruminants account for a major proportion of total greenhouse gas emissions from Australian agriculture. Selection for improved feed efficiency in beef and dairy cattle, measured as residual feed intake (RFI) has been suggested as a potentially novel approach to reducing CH_4 emissions without compromising animal production. Ninety Limousin × Friesian yearling heifers, initially selected based on sire EBVs for RFI, were ranked on the basis of phenotypic RFI, calculated over an 82-day period while consuming an ad libitum 30:70 maize silage: concentrate diet. Ruminal CH_4 emissions were measured from the most efficient (Low RFI; LRFI; n=16) and least efficient (High RFI; HRFI; n=16) animals using the SF^6 tracer technique, across 3 diet types, (1) grass silage, (2) grazed pasture and (3) on a 30:70 Maize silage: Concentrate TMR identical to the diet upon which they were originally ranked for RFI. There was no difference ($P > 0.05$) in DMI and CH_4 emissions between the groups during periods 1 and 2, however the LRFI group had lower DMI when corrected for metabolic liveweight ($BW^{0.75}$, $P = 0.022$) in period 3.

A trend towards higher CH_4 emissions in the LRFI group was also detected when expressed in g/kg DMI per day in period 3 ($P = 0.052$). Results suggest CH_4 emissions would not be reduced by genetic selection for RFI, however selection for phenotypically low RFI animals has benefits in terms of increased animal performance whilst reducing feed intake on a $BW^{0.75}$ basis. This is of both economic and environmental importance as the animals consume less feed while maintaining similar levels of performance, and overall system CH_4 emissions per unit of product (emissions intensity; Ei) should be reduced.

Introduction

Feed expenditure accounts for 43-67% of total variable costs in Australian dairy systems (Ho *et al* 2005). Therefore feed efficiency is potentially an important factor affecting profitability in Australian dairy herds. The use of Residual Feed Intake (RFI) as a selection tool for improved feed efficiency has become commonplace in beef production systems around the world (Herd and Richardson 2004, Kelly *et al* 2010). RFI is calculated as the difference between the actual feed intake of an animal and its expected feed intake based on its size and growth rate (Kelly *et al* 2010). It is genetically independent of growth rate and mature size, and is a moderately heritable trait (h^2 = 0.26-0.43, Crews 2005). While the impact of selection for RFI in dairy cattle is less than in beef animals due to a higher proportion of feed energy being expressed in milk than is retained in liveweight gain (Waghorn and Hegarty 2011), evidence shows that substantial genetic variation in RFI exists, and the magnitude of this variation is such that it is a viable selection trait in dairy breeding programs (Williams *et al* 2011). Interest in the potential to use RFI as a selection trait for dairy breeding programs in Australia has increased in recent years, and there have been a number of RFI related studies conducted on dairy cattle consuming similar forage based diets to southern Australian dairy systems (Williams *et al* 2011, Waghorn *et al* 2012, Green *et al* 2013).

The agricultural sector in Australia is responsible for 16% of total Greenhouse gas (GHG) emissions annually (NSW DPI 2009). Moreover, ruminal methanogenesis accounts for 65% of the total GHG emissions from agriculture in Australia. Methane emissions from ruminants represent a substantial loss of dietary energy, with approximately 6-10% of the total gross energy intake of dairy cows lost as CH_4 (Eckard *et al* 2010).

Therefore reducing CH_4 emissions should also improve the efficiency of feed utilization in ruminants, as well as providing benefits in terms of reducing the overall environmental impact of animal agriculture in Australia. This study assessed the potential to reduce CH_4 emissions from animals by phenotypically ranking them for RFI into efficient and inefficient groups, and investigating whether there were any differences between groups in CH_4 emissions.

Furthermore, we assessed dry matter intake (DMI) and CH_4 emissions across 3 contrasting diet types, to see if the rankings remained consistent when the animals were offered feed of differing quality.

Materials and methods

This study was conducted as part of a larger project which examined the biological control of energetic efficiency in growing heifers (Kelly *et al* 2010). To summarise, 90 Limousin x Friesian heifers, initially selected on the basis of sire estimated breeding value (EBV) for RFI, were housed and fed a total mixed ration (TMR) *ad libitum* of maize silage and concentrate (30:70 DM basis). The animals were housed for 112 days during which DMI and average daily gain (ADG) were electronically recorded, before being retrospectively ranked on phenotypic RFI, defined as the deviation of predicted daily DMI from actual DMI according to Crews (2005). The 16 highest (inefficient; HRFI) and 16 lowest (efficient; LRFI) ranked animals were selected for the current study. Detailed analysis of the 32 selected animals is shown in table 1.

Three successive periods of 40, 57 and 41 days followed during which the animals were offered *ad libitum* grass silage (PS; period 1), Pasture (PAST; predominantly perennial ryegrass sward; period 2) and an identical concentrate and maize silage TMR (TMR; period 3) as that upon which the animals were initially ranked for RFI. Methane production was measured from each individual animal (figure 1) for 5 consecutive days at the end of each period using the SF^6 technique as described by Johnson *et al* (1994). Individual DMI was also recorded for each animal during the CH_4 measurement period. The animals were housed for periods 1 and 3, during which daily DMI was recorded using an electronic feeding system. For period 2, DMI for each animal at pasture was estimated using the n-alkane technique of Dove and Mayes (2006).

Liveweight was recorded as an average value over 2 consecutive days for each individual animal on the final 2 days of each CH_4 measurement period.

Figure 1. Methane collection at pasture

Feed samples were collected daily during all CH_4 measurement periods, and subsequently analysed for DM, CP, NDF, ADF, EE and gross energy (GE). Water soluble carbohydrate (WSC) content was also measured in the fresh pasture fed in period 2.

Results

Methane emissions and daily DMI from the HRFI and LRFI groups during CH_4 measurement periods 1-3 are summarised in Table 2. Dry matter intake between the HRFI group and the LRFI group did not differ during periods 1 and 2, however in period 3 the HRFI group consumed more feed per unit of metabolic liveweight ($W^{0.75}$; $P < 0.05$).

Methane emissions between the HRFI group and the LRFI group did not differ significantly during any period ($P > 0.05$), regardless of the method of expression.

However a trend approaching statistical significance towards higher CH_4 emissions from the LRFI group was detected in period 3, when CH_4 was expressed as g/kg of DMI ($P = 0.052$) and g/kg of gross energy intake (GEI; $P = 0.051$). However this difference was not apparent in period 3 when expressed in g/kg $W^{0.75}$ ($P = 0.41$).

Table 1. Pre-experimental data on selected animals (based on an 82 day recording period)

Traits	Mean	SD	HRFI[a]	LRFI[a]	SEM[b]	P-value
No. of animals			16	16		
DMI, kg/d	6.82	1.17	7.48[c]	6.16[d]	0.2	**<.0001**
Metabolic mid-weight, $kg^{0.75}$	63.81	6.91	63.75	63.64	1.24	0.95
ADG, kg/d	1.51	0.13	1.50	1.52	0.03	0.64
Final LW, kg	315.73	37.87	315.40	315.89	7.16	0.96
Feed conversion ratio, kg of DM/kg of ADG	4.48	0.64	4.98[c]	4.07[d]	0.1	**<.0001**
Residual feed intake, kg/d	-0.01	0.67	0.65[c]	-0.70[d]	0.07	**<.0001**

[a]HRFI = high RFI group; was > 0.5 SD above the mean; [a]LRFI = low RFI group; was 0.5 SD below the mean.
[b]SEM = Standard error of the mean. [cd] Least squares means within rows with different superscripts differ.

Table 2. Effect of phenotypic ranking for residual feed intake on dry matter intake and ruminal methane emissions.

	HRFI[a]	LRFI[a]	SEM[b]	P-value
Period 1(grass silage)				
DMI kg/d	5.68	5.37	0.413	0.45
DMI g/kg $W^{0.75}$	71.2	66.4	4.91	0.34
CH_4 g/d	130	142	9.9	0.25
CH_4 g/kg DMI	23.6	27.2	2.35	0.14
CH_4 g/kg $W^{0.75}$	1.63	1.78	0.127	0.24
CH_4 %GEI	6.03	6.95	0.560	0.14
Period 2 (pasture)				
DMI kg/d	6.52	6.55	0.337	0.92
DMI g/kg $W^{0.75}$	75.4	75.1	3.87	0.95
CH_4 g/d	117	123	2.6	0.59
CH_4 g/kg DMI	18.4	18.8	1.58	0.81
CH_4 g/kg $W^{0.75}$	1.36	1.42	0.124	0.67
CH_4 %GEI	5.04	5.15	0.435	0.80
Period 3(TMR)				
DMI kg/d	10.43	9.63	0.511	0.13
DMI g/kg $W^{0.75}$	112.3	102.6	3.99	**0.02**
CH_4 g/d	190	204	12.4	0.26
CH_4 g/kg DMI	18.5	21.3	1.37	**0.05**
CH_4 g/kg $W^{0.75}$	2.06	2.17	0.138	0.41
CH_4 %GEI	5.20	5.99	0.384	**0.05**

[a]HRFI = high RFI group; was > 0.5 SD above the mean; [a]LRFI = low RFI group; was ⍰0.5 SD below the mean.
[b]SEM = Standard error of the mean

Discussion

The potential to reduce CH_4 emissions from ruminants without negatively impacting on farm profit margins has gained increasing focus in Australia in recent years, and is likely to attract continued interest as the Australian dairy industry aims to improve its sustainability and limit its carbon footprint. Numerous approaches have been investigated to reduce CH_4 emissions in ruminants, mainly based around dietary manipulation strategies. These include the addition of various fats and oils to ruminant diets, feeding forages of lower fibre contents and adding supplements such as fumaric acid to increase propionate production in the rumen and therefore lower CH_4 production (Eckard *et al* 2010). Many of these strategies have only a temporary effect on CH_4 production and are often cost prohibitive.

The possibility of using genetic selection for improved RFI, as a CH_4 mitigation strategy has gained traction in recent years. This strategy has significant appeal as it should theoretically result in permanent and cumulative changes in CH_4 output (Fitzsimons *et al* 2013).

However, published evidence to date regarding the use of RFI as a tool to reduce ruminant CH_4 emissions is unclear. Hegarty *et al* (2007), and Nkrumah *et al* (2006) have reported reduced CH_4 emissions from cattle selected for RFI that were fed high grain diets, while Jones *et al* (2011) showed that cattle selected for low RFI grazing high digestibility pastures produced less CH_4 than their high RFI counterparts.

However, Waghorn and Hegarty (2011) showed no differences in CH_4 emissions between 2 groups of Holstein/Friesian cows divergently selected for RFI, while Munger and Kreuzer (2008), reported a weak relationship between RFI and CH_4 emissions, with large individual variation in CH_4 production in dairy cows.

Our results showed no differences in DMI between groups when the animals were fed grass silage and pasture. This was in agreement with the work of Jones *et al* (2011) who reported no difference in DMI at pasture between cows selected based on EBVs for extremes in RFI.

During period 3 however, when the animals were consuming an identical diet to the one upon which the original rankings were based, the LRFI group consumed 9% less feed than their HRFI counterparts when expressed as g/kg $W^{0.75}$ (P = 0.02). Fitzsimons *et al* (2013) and Hegarty *et al* (2007) showed similar differences in feed intake between groups of animals phenotypically selected for divergent RFI.

Based on our results it appears that any inherent differences in RFI between LRFI and HRFI groups are not expressed when the animals are offered lower energy pasture and grass silage diets. This may also be due to the poorer feed intake characteristics of grass silage in comparison to higher energy, more digestible diets, while the n-alkane technique used to estimate pasture DMI in period 2 may not have been sufficiently accurate to detect any differences had they existed.

Our data showed no differences in methane production (CH_4 g/day) between groups, during any of the measured periods, which was consistent with the findings of Waghorn and Hegarty (2011). However this contrasted with Fitzsimons *et al* (2013) and Hegarty *et al* (2007) who both showed low RFI groups of cattle produced less CH_4 than their high RFI counterparts.

Methane production expressed as a % of DMI, GEI and $W^{0.75}$ did not differ between groups on any of the diets measured in the current study, although somewhat surprisingly, trends towards higher CH_4 emissions in the LRFI group were detected when expressed as a % of DMI and GEI (table 2). The reasons for this are unclear, although Waghorn and Hegarty (2011) also reported numerically higher CH_4 emissions in 2 different low RFI groups of dairy cows when compared to corresponding high RFI groups consuming alfalfa cubes and pasture respectively. Furthermore, they used respiration calorimeters, widely considered a more accurate method of measuring CH_4 emissions than the SF^6 technique that was used in our study and the work of Hegarty *et al* (2007) and Fitzsimons *et al* (2013).

Analysis of rumen VFA profiles collected from each animal at the end of each CH_4 measurement period (Mc Donnell 2008), showed that the LRFI group tended towards higher acetate concentrations and lower propionate concentrations than the HRFI group which may indicate that potentially inherent differences in VFA concentrations existed between the 2 groups. It is widely established that higher levels of acetate and lower levels of propionate in the rumen result in increased levels of CH_4 lost as GE (Eckard *et al* 2010).

Based on the results of our study, it appears that RFI does not affect CH_4 production above and beyond the level of DMI. This position is in accordance with the conclusions of Fitzsimons *et al* (2013), Waghorn and Hegarty (2011) and Hegarty *et al* (2007), who all deduced that any reduction in CH_4 emissions associated with low RFI cattle is merely a function of their reduced dry matter intake.

Notwithstanding this, selection for low RFI beef and dairy cattle should result in a reduction in CH_4 emissions because of the improved emissions intensity (Ei) associated with high producing animals (Waghorn and Hegarty 2011). The associated productivity benefits related to improved residual feed intake in dairy cows mean that its inclusion as a selection trait in future dairy breeding programs in Australia should have the dual benefit of increasing productivity and decreasing the carbon footprint of the Australian dairy industry. However, further research is also required to establish the consequences of selection for RFI on other important traits in dairy cows such as fertility, and to ensure it does not have a negative impact on the normal biological processes a commercial dairy cow is expected to perform (Williams *et al* 2011).

Acknowledgements

This work was carried out in Ireland and was funded by the National Development Plan, through the Research stimulus fund, administered by the Department of Agriculture, Fisheries & Food, Ireland.

References

Crews Jr D.H. Gen & Mol Research. 4(2), 152.

Dove H. and Mayes R.W. (2006) Nature Protocols. 1, 1680

Eckard R.J., Grainger C., and De Klein C.A.M. (2010) Livestock Sci. 130, 47.

Fitzsimons C., Kenny D.A., Deighton M.H., Fahey A.G. and McGee M. (2013). J of Ani Sci. 91, 5789.

Green T.C., Jago J.G., Macdonald K.A. and Waghorn G.C. (2013) J Dairy Sci. 96, 3098

Hegarty R.S., Goopy J.P., Herd R.M. and Mc Corkell B. (2007) J of Ani Sci. 85, 1479.

Ho C., Nesseler R., Doyle P., and Malcolm B. (2005) Aust Farm Bus Magagement J. 2, 59.

Johnson K., Huyler M., Westburg H., Lamb B and Zimmerman P. (1994) Envir Sci & Tech. 28, 359.

Jones F.M., Phillips F.A., Naylor T, Mercer N.B. (2011) Ani Feed Sci & Tech. 166-167, 302.

Kelly A.K., McGee M., Crews Jr D.H., Fahey A.G., Wylie A.R., and Kenny D.A. (2010) J of Ani Sci. 88, 109.

Mc Donnell R., (2008) Master's thesis, University College Dublin, Ireland.

Munger A and Kreuzer M (2008) Aust J of Expt Agr 48, 77.

Nkrumah J.D., Okine E.K., Mathison G.W., Schmid K., Li C., Basarab J.A., Price M.A., Wang Z., and Moore S.S. (2006) J of Ani Sci. 84, 145.

N.S.W. DPI (2009) Reducing methane from Ruminants; The next steps forward. Available at www.dpi.nsw.gov.au

Richardson E.C. and Herd R.M. (2004) Aust J of Expt Agr. 44, 431.

Waghorn G.C. and Hegarty R.S. (2011) Ani Feed Sci & Tech. 166-167, 291.

Waghorn G.C., Macdonald K.A., Williams Y., Davis S.R. and Spelman R.J. (2012) J Dairy Sci. 95, 1462

Williams Y.J., Pryce E.J., Grainger C., Wales W.J., Linden N., Porker M., and Hayes B.J. (2011) J Dairy Sci. 94, 4715

INSIDE THE MIND OF THE COW: UNDERSTANDING VOLUNTARY COW TRAFFIC BEHAVIOUR IN A PASTURE-BASED AUTOMATIC MILKING SYSTEM

V.E. Scott[AC], K.L. Kerrisk[A], P.C. Thomson[B] and S.C. Garcia[A]

[A]Dairy *Science Group, Faculty of Veterinary Science, The University of Sydney, Camden NSW 2567*
[B]*ReproGen – Animal Bioscience Group, Faculty of Veterinary Science, The University of Sydney, Camden NSW 2567*
[C]*Corresponding author. Email: tori.scott@sydney.edu.au*

Abstract

Feed is a strong incentive for voluntary cow traffic in automatic milking systems, and it is particularly important to encourage cow traffic in the dairy where space is limiting and the risk of congestion is high. Inefficiencies in cow traffic at the dairy could lead to cows spending long periods of time off pasture and on concrete, thereby increasing the risk of compromised milk production and herd health. This study investigated whether differences in production, management and cow behaviour impacted on the likelihood of a cow spending a prolonged period of time in the pre-milking yard of a pasture-based automatic milking system. Results indicated that as the number of milkings associated with the management practices of fetching and encouraging cows to present for milking increased, the probability of a cow consistently spending a long period of time waiting before milking also increased. The probability of consistently spending a shorter period of time in the pre-milking yard increased as the number of milkings associated with daytime as well as active behaviours increased. Cow traits, such as milk yield, parity and stage of lactation, did not affect the probability of a cow consistently spending long periods of time in the pre-milking yard. Through altering management practices that target cows identified as poorer traffickers within the dairy facility, it may be possible to reduce the time cows spend in the pre-milking yard and encourage more efficient traffic through the dairy.

Introduction

A typical pasture-based automatic milking system (AMS) operates with voluntary cow traffic, where cows set their own daily routine, traffic (move) throughout the farm system with little human assistance, and achieve milkings distributed across the 24 h day.

Central to this management practice is the need to encourage cow traffic. While a range of incentives are available, feed is arguably the most successful incentive, where improvements in cow traffic have been achieved through the strategic placement of different feed sources, such as supplementary feed (Jago *et al* 2007; Lyons *et al* 2013b), pasture allocations (Lyons *et al* 2013a) and concentrates offered at milking (Scott *et al* 2014).

In addition to managing voluntary cow traffic, pasture-based systems must also overcome challenges presented by long walking distances, weather conditions, and large herd size. As herd size grows, the risk of congestion in areas of limiting space, such as the dairy, increases and waiting time could be prolonged, resulting in reduced cow traffic, reduced milk production, compromised herd health and system inefficiencies.

Furthermore, social interactions/hierarchy almost certainly affects cow traffic and the ability to volunteer for milking, where dominant cows have been shown to spend less time in the waiting area of a single-box AMS prior to milking (Ketelaar-de Lauwere *et al* 1996; Melin *et al* 2006).

Several studies aiming to encourage voluntary cow traffic in the pre-milking yard of a robotic rotary (RR; DeLaval AMR™ - Automatic Milking Rotary, DeLaval, Tumba, Sweden) investigated the use of feed incentives offered at the dairy, during milking (Scott *et al* 2014), and in the paddock (Scott *et al*, unpub. data).

Despite the use of feed as an incentive, it was observed that some cows still voluntarily spent long periods of time (> 2 h) in the pre-milking yard. It is important to understand why this occurred in order to minimise the risk of congestion by cows 'unnecessarily' waiting in the yard.

A retrospective study into the voluntary waiting times of cows in the pre-milking yard was conducted using data from a study in which cows were offered a feed incentive either before (PRE) or after (POST) milking.

The aim of this investigation was to determine whether there were any similarities between cows that had relatively consistent voluntary waiting times, and to better understand why cows might be voluntarily spending consistently long periods of time in the pre-milking yard of a pasture-based RR system. It was hypothesised that feed treatment would not affect the consistency and variability of an individual cow's voluntary waiting time. Cow behaviour, production and management factors were also considered in this study.

Materials and Methods

A five week field study was conducted in September and October 2011 at the Camden AMS Farm, located on the Elizabeth Macarthur Agricultural Institute (NSW Department of Primary Industries). Ethics approval was granted through the Elizabeth Macarthur Agricultural Institute Animal Ethics Committee prior to the study commencing.

Cows were managed as a single herd of 175 cows of mixed breed (Holstein and Illawarra) and mixed age (30% primiparous; average days in milk was 174.4 days) with a minimum of 7 months experience milking under voluntary traffic conditions on a prototype RR. The average 7-day milk yield was 20.7 L/cow per day, while average milking frequency was 1.6 milkings/cow per day. Cows were fed a target dry matter intake of approx. 23 kg/cow per day, described by Lyons *et al* (2013b).

To assess the effect of offering supplementary feed either before or after milking, cows were individually allocated into one of two treatments, being PRE (offered feed before milking, directly following returning from pasture), or POST (offered feed after milking). Treatments were balanced for days in milk and milk yield. A cross-over design, consisting of two periods of 13 days each (7 habituation and 6 data collection days), enabled data to be collected from all cows across both treatments.

Following data collection, voluntary waiting time was calculated per cow per milking (the length of time a cow spent in the pre-milking yard during which she could freely volunteer for milking – i.e. the RR was available to accept cows for milking).

The median voluntary waiting time per cow, using all her milkings, was determined and used to label cows into one of three groups ('waiter class'); Short (0-66 min), Mid (67-119 min) and Long (120+ min), forming the outcome variable.

Waiter class data were analysed using an ordinal logistic regression (OLR) procedure in GenStat 15th Edition (VSN International, UK).

Note that for each cow all terms in the model were presented as proportions of the total data available. A stepwise backward elimination procedure was used in the model selection (full model not shown). Probabilities for each term in the final model were calculated in ASReml v. 3.1 (VSN International, UK), being

$$\log_e\left(\frac{P(Y \le k)}{P(Y > k)}\right) = \theta_k - \begin{pmatrix}\beta_1 \text{Ppre} + \beta_2 \text{Pday} + \beta_3 \text{Pfetched} + \\ \beta_4 \text{Pencouraged} + \beta_5 \text{Pactivity}\end{pmatrix}$$

where $P(Y \le k)$ is the probability of having a waiting class of k or less (the ordered classes being Short, Mid and Long waiter); θ_k is the constant that varies according to the waiting class of k or less; Ppre is the proportion of milkings that were associated with the PRE treatment; Pday is the proportion of milkings that were associated with the day milking session; Pfetched is the proportion of milkings that were associated with a cow being fetched from the paddock to the dairy; Pencouraged is the proportion of milkings that were associated with a cow being encouraged onto the RR platform at the end of a milking period; and Pactivity is the proportion of milkings that were associated with each behavioural activity (active, ruminating and idle).

Results

Treatment did not affect the probability of cows being in any one waiter class ($P = 0.215$).

As the proportion of milkings recorded during the day increased, the probability of a cow being in the Long waiter class decreased ($P = 0.007$; Figure 1).

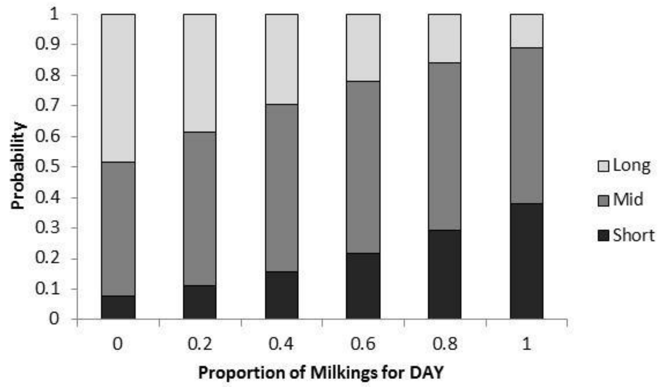


Figure 1. The probability of a cow being in the Long, Mid or Short waiter class as the proportion of milkings that occurred during the day increased for cows in a pasture based automatic milking system.

The probability of a cow being in the Long waiter class increased with an increase in the proportion of milkings associated with being fetched from the paddock ($P < 0.001$; Figure 2). When more than 80% of milkings were associated with being fetched, the probability of being in the Long waiter class was greater than 0.84, and it was less than 0.01 and 0.14 for the Short and Mid classes respectively.

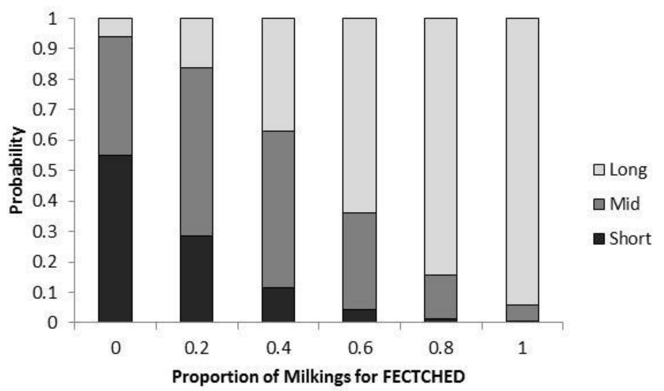


Figure 2. The probability of a cow being in the Long, Mid or Short waiter class as the proportion of milkings that were associated with being fetched from pasture increased for cows in a pasture based automatic milking system.

Similarly, when the proportion of milkings associated with being encouraged onto the RR platform increased, the probability of being in the Long waiter class also increased ($P < 0.001$; Figure 3).

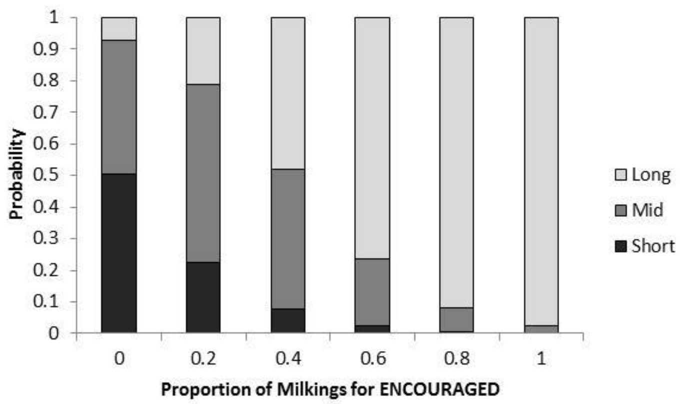


Figure 3. The probability of a cow being in the Long, Mid or Short waiter class as the proportion of milkings that were associated with being encouraged onto the RR platform increased for cows in a pasture based automatic milking system.

Cow behaviour effected the probability of cows being in the Long, Mid or Short waiter class ($P = 0.011$; Figure 4).

As the proportion of observations in which a cow was recorded as 'active' increased, the probability of being in the Short waiter class also increased (Figure 4a), while it decreased as the proportion of observations in which a cow was recorded as idle increased (Figure 4b).

Ruminating did not have an effect on the probability of being in any of the waiter class.

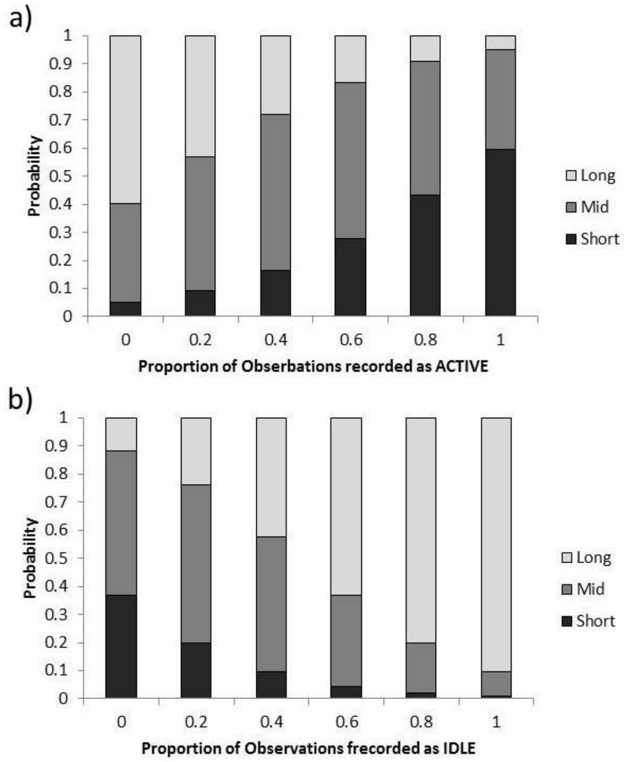


Figure 4. The probability of a cow being in the Long, Mid or Short waiter class as the proportion of observations in which a cow was recorded as being a) active; and b) idle, increased for cows in a pasture based automatic milking system.

Discussion

Results indicated that treatment did not affect the waiter class a cow was in, despite cows having a shorter average voluntary waiting time in the

POST treatment (Scott *et al* 2013). This by no means discounts the success or usefulness of feed as a management tool in encouraging voluntary cow traffic. Instead, it appears that, although cows reduced their waiting time when in the POST treatment, large variation in waiting time across the herd still exists, meaning that a feed incentive may not be the most appropriate, and certainly not the only, incentive available when targeting traffic amongst the poorer trafficking cows within the herd.

Interestingly, management practices were shown to have the greatest effect on the probability of a cow being in the Long waiter class. It may be that cows learn to be poor traffickers through regular fetching and being encouraged onto the RR platform, however it is more likely that they are less motivated to present for milking (perhaps not finding the offer of feed as appealing as the bulk of their herd mates) or that previous experience has made them hesitant.

Previous experience on the RR was not investigated in the present study, and therefore it is difficult to say to what extent previous experience impacts the traffic of individual cows, however training is known to improve cow traffic (Jago and Kerrisk 2011). Further research into best-practice methods for training cows for milking on a RR could assist in improving traffic onto the RR platform while alternate management methods, such as a priority laneway in which poor traffickers are sent to bypass the main pre-milking yard, could also prove beneficial.

It was not surprising that cows that tended to be milked during the day, or observed to be in active behaviours, had a greater probability of being in the Short or Mid classes than cows that were milked at night or observed to be idle (including resting), respectively. During the day, human activity at the dairy tends to be higher and could inadvertently encourage cows to present for milking more rapidly than at night. Active cows are also likely to be more motivated, and therefore could explain why the probability of being in the Short or Mid classes was higher. Additionally, cows may choose to rest during the night, further explaining results in the present study.

Conclusion

Management practices appear to have the greatest association on whether a cow consistently has long voluntary waiting times in the pre-milking yard, and it therefore may be possible to improve traffic through adjusting current management practices. Research into the use of a priority laneway could be one solution to addressing slow traffic in individual cows at the dairy, while minimising the number of cows fetched from the paddock through modifying pasture allocations or paddock opening times could also prove beneficial.

Acknowledgements

This work was supported by the funders of the FutureDairy program (Dairy Australia, NSW Department of Primary Industries, DeLaval and The University of Sydney), along with the Dairy Research Foundation.

References

Jago, J.G., Davis, K.L., Copeman, P.J., Ohnstad, I., and Woolford, M.M (2007). J. Dairy Res. 74(4):492-499.

Jago, J.G., and Kerrisk, K.L. (2011). Appl. Anim. Behav. Sci. 131:79-85.

Ketelaar-de Lauwere, C.C., Devir, S. and Metz, J.H.M (1996). Appl. Anim. Behav. Sci. 49(2):199-211.

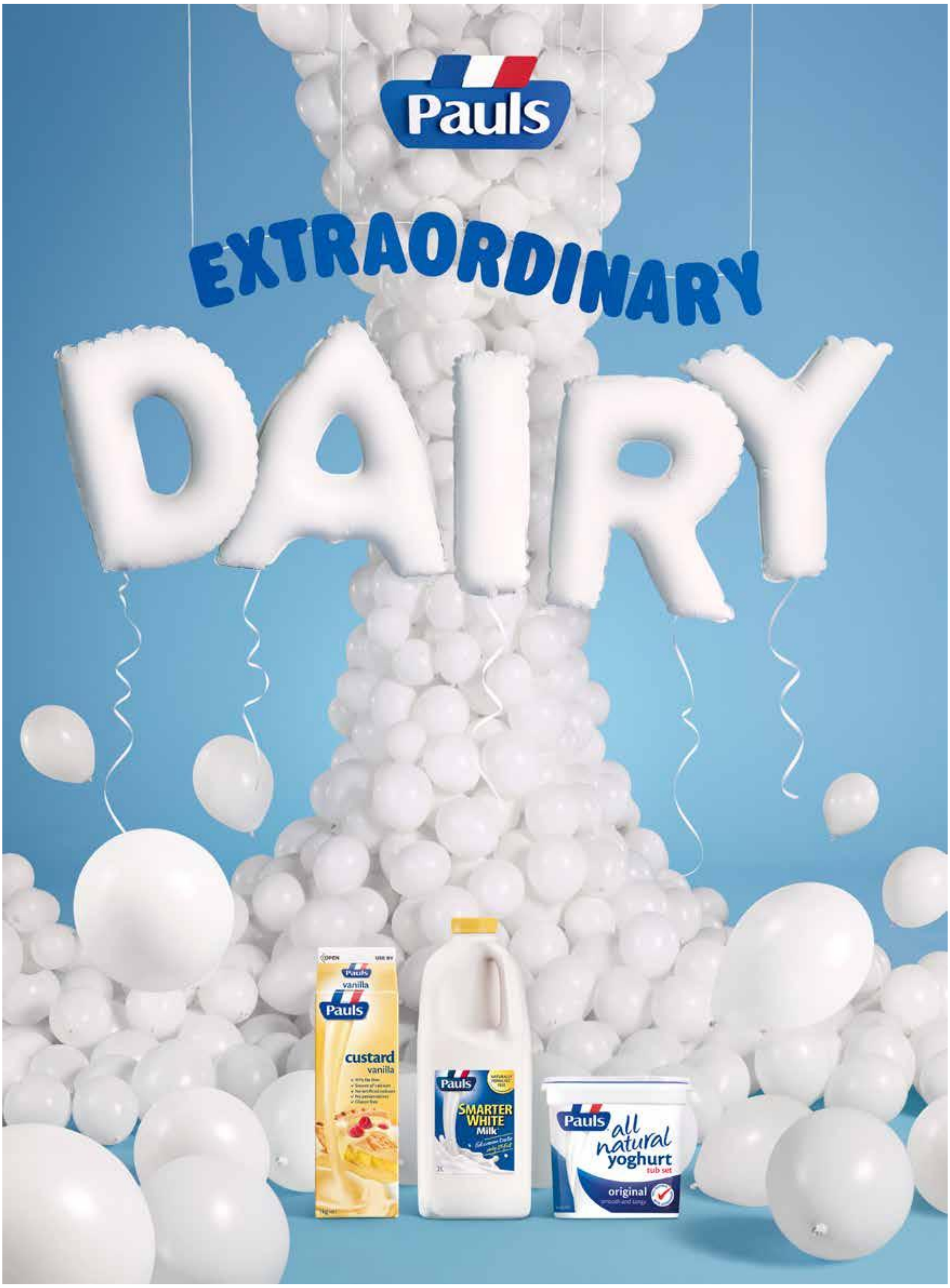
Lyons, N.A., Kerrisk, K.L., and Garcia, S.C. (2013a). J. Dairy Sci. 96(7):4494-4504.

Lyons, N.A., Kerrisk, K.L., and Garcia, S.C. (2013b). J. Dairy Sci. 96(7):4397-4405.

Melin, M., Hermans, G.G.N., Pettersson, G., and Wiktorsson, H. (2006). Appl. Anim. Behav. Sci. 96(3-4):201-214.

Scott, V.E., Kerrisk, K.L., Garcia, S.C., and Thomson, P.C. (2013). Dairy Research Foundation: Current topics in Dairy Production 18:104-109.

Scott, V.E., Thomson, P.C., Kerrisk, K.L., and Garcia, S.C. (2014). J. Dairy Sci. 97(3):1481-1490.


Pauls
EXTRAORDINARY
DAIRY
Pauls
vanilla
custard
vanilla
Pauls
SMARTER
WHITE
Milk
Pauls
all
natural
yoghurt
tub set
original

THE IMPACT OF MILKING ORDER ON THE QUALITY AND QUANTITY OF PASTURE ACCESSED

B.A. Scott[A1], A. Camacho[A], C.E.F. Clark[A], H. Golder[B], J. Molfino[A], K.L. Kerrisk[A], I. Lean[B], S.C. Garcia[A], A. Chaves[A] and E.Hall[A].

[A]*Dairy Science Group, Faculty of Veterinary Science, The University of Sydney, Camden NSW 2570, Australia*
[B]*SBScibus, 2 Broughton Street, Camden NSW 2570, Australia*
[1]*Corresponding author. Email: bsco5955@uni.sydney.edu.au*

Abstract

Previous studies have shown differences in the nutritive value through successive layers of perennial ryegrass. Furthermore, there is a consistent milking order for cows both within and between days. The objective of this study was to determine the effects of milking order on the quality and quantity of pasture accessed. Two experimental trials were conducted over a 9-day period. The first study investigated the association between milking order and time of paddock access. The second study investigated paddock access, and the quality and quantity of pasture available to cows over time. Results indicate that milking order is highly associated with timing of paddock entry (R^2 = 0.92) with at least 36% of pasture to ground level being depleted before the last cow entered the paddock. The nutritive values varied overtime, with the last cows accessing pasture 4% lower in crude protein (CP), and 5% and 4% higher in neutral detergent fibre (NDF) and acid detergent fibre (ADF) respectively, compared to cows accessing the pasture first.

Introduction

The depletion of a pasture sward by cattle typically occurs in successive layers, from the tip of the youngest leaf (Wade & Carvalho, 2000), then progressively down the sward until reaching the residual biomass level (Jouven, 2006). The chemical composition of a perennial ryegrass sward varies between the successive layers, with the higher end of the fraction typically containing more crude protein and less neutral detergent fibre than lower fractions (Delagarde *et.al*, 2000). As there is a consistent milking order for cows both within and between days (Botheras, 2006), the last cows being milked may be consistently arriving to a paddock later and accessing pasture of differing nutritive value compared to those consistently arrive to a paddock first after milking.

The objectives of this study were to determine the association between milking order and paddock access order, and the change in the quantity and nutritive value of pasture accessed by dairy cows over the time of paddock access.

Materials and methods

The research was conducted over a 9-day trial period at Corstorphine dairy farm, University of Sydney, Camden. Ethics approval (Project: 569) was granted through the University of Sydney Animal Ethics Committee.

Cows were offered a total dry matter intake of 25kg DM/cow consisting of grain-based concentrate (7kg/cow/d), a mixed crop of sorghum (*Sorghum bicolor*) and millet (*Echinochloa utilis*) after the morning (AM) milking, and kikuyu pasture (*Pennisetum clandestinum*) supplemented with oaten silage after the afternoon (PM) milking.

Cow ID and the time of entry to the kikuyu pasture paddock was recorded at the paddock gate. Milking order was recorded automatically at the dairy.

To determine pasture depletion across time, pre-grazing compressed height was measured across the whole paddock with a rising plate metre (>50 counts; Farmworks, Palmerston North, New Zealand) and extended sward height (base to highest leaf) with a ruler.

These measurements were repeated every 15 minutes from time the first cow entered the paddock until the last cow had entered to determine pasture depletion across the paddock. Post-grazing rising plate meter height and extended sward height were determined the subsequent day to determine the past grazing height.

To determine the variance in nutritive value down the pasture sward and to calibrate extended leaf height with pasture mass (kgDM/ha), nine 50 x 50cm quadrats were assigned as representatives of the 3 different levels of pasture within the paddock; low (L) (~20-30cm), medium (M) (~30-45cm) and high (H) (>50cm) resulting in 3 replicates of each of height.

In each quadrat, the grass height was randomly measured 6 times with the ruler and once with the plate metre. The quadrat was cut as close to ground level as possible with an Ozito HTL-072 Cordless Hedge Trimmer and Grass shearer.

The grass was removed and bagged taking care to maintain the vertical structure of the sward, labelled and taken for analysis. The remaining stubble heights were randomly measured 6 times and all stubble was then removed for analysis.

All pasture samples were weighed and then pooled based on treatments and cut into 5cm fractions, The first 5cm fraction from ground level was related to the stubble height, then cut into 5cm fractions (5-10, 10-15, 15-20cm up the whole sward).

The fractions were weighed (fresh weight) and then dried at 60°C for 48hours. They were removed from the oven and re-weighed (dry weight) to determine the percentage dry matter. Samples were individually ground to ~1mm using a C & N Laboratory mill.

Crude Protein (CP) was analysed using FP628 Food/Protein Analyzer (LECO, Michigan, USA) following the manufactures guidelines. Both Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) were analysed using ANKOM^{200} Fibre Analyzer (ANKOM, New York, USA)

Statistical Analysis

Data was analysed using Restricted Maximal Likelihoods (REML) procedure (Genstat, v.14; VSN International Ltd, Hemel Hempstead, Hertfordshire, UK). To determine the change in nutritive values of CP, NDF and NDF, the level of pasture in the paddock (L, M, H) and fraction length (5cm fraction) were used as fixed effects, and day as a random effect.

To determine the change in pasture availability overtime, time after entry and day were fixed effects. From these results, a regression analysis was performed on CP, NDF and ADF to determine the nutritive values over time.

Results

Milking order was highly associated with paddock access order (R^2 = 0.92). Cows that entered the paddock earlier had greater available pasture than those that entered last as per the significant effect (P<0.001) of time of paddock entry on pasture available to ground level (kgDM/ha) (Figure 1).

Cows depleted 70% of pre-grazing pasture available relative to post-grazing available over the duration of cow entry into the paddock. Mean post-grazing pasture available was 2,516 kgDM/ha. The rate of cow entry over time was relatively constant.

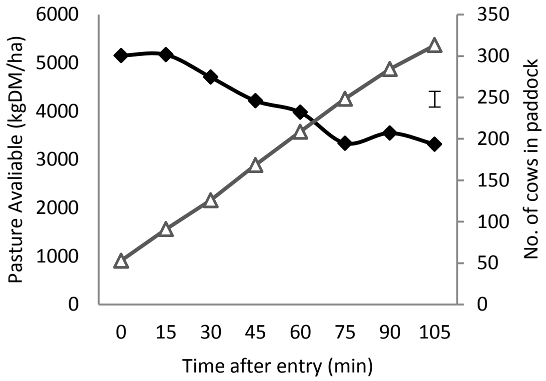


Figure 1. Depletion of pasture (kgDM/ha;⍰) and the number of cows in the paddock (Δ) against time after entry. The error bar indicates the average standard error of the difference for kgDM/ha.

There was a significant effect (P<0.001) of fraction length on crude protein, NDF and ADF content with the highest fraction containing double the crude protein and two thirds of the ADF than the lowest fractions.

There was an effect (P<0.001) of pasture level on CP (Figure 2a) and ADF (Figure 2b) but there was no effect of pasture level on NDF.

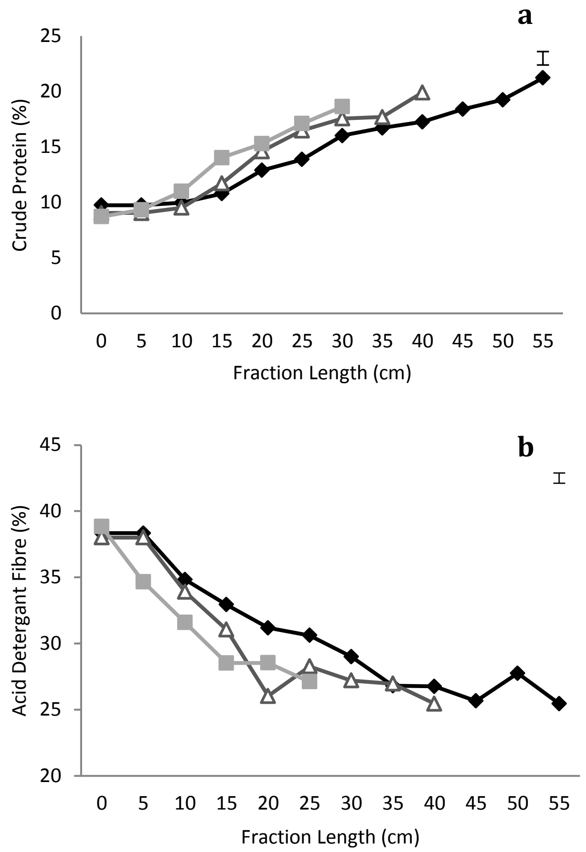


Figure 2a and b. Variation in crude protein (%) (a) and ADF (%) (b) for each pasture level: H (⍰), M (Δ) and L (⍰) in relation to fraction of the sward. The error bar indicates the average standard error of the difference.

The average CP across the paddock decreased by 4% over the duration of cow entry, whilst the average NDF and ADF content increased 5% and 4%, respectively (Table 1).

Discussion

Our work showed that over time the quantity and nutritive value of pasture accessed by dairy cows varied substantially. Pasture was depleted to ground by 36% during the duration between the first and last cow entering the paddock.

Table 1. Variation in nutritive values (CP, NDF and ADF) and pasture depletion (fraction length) over time

Time after entry	CP (%)	NDF (%)	ADF (%)	Fraction length (cm)
0	19	60	26	42
15	19	60	26	42
30	18	62	27	37
45	17	63	28	34
60	16	64	29	31
75	15	65	30	27
90	15	65	29	28
105	15	65	30	26
SED	1.3	3.13	2.32	2.454

Paddock access was strongly associated with milking order. Given that there is a constant milking order within, and between days (Botheras, 2006), our results allow us to determine the nutritive values of the pasture that individual cows have access to overtime.

Our findings align with Delagarde (2000.), whereby the higher proportion of the sward contained significantly more CP, and less NDF and ADF than lower fractions. The chemical composition of kikuyu in this study displayed large variations between the lowest fraction and the top of the sward. As the fraction length increased across treatments, CP increased whilst NDF and ADF decreased. Furthermore, we were able to demonstrate that the effect of treatment heights for kikuyu pasture altered the nutritive values for CP and ADF. Differences in nutritive value for pasture level can be explained by the increase in leaf tillers, stem and dead material content as kikuyu plant regrows, as shown by Reeves (1996).

Throughout the period of paddock access, we were able to show that the nutritive value of kikuyu pasture available decreased in CP for cows accessing the paddock last, and increased in NDF and ADF. These findings could explain the variation in milk yield between the first and last cows seen in the milking order (Botheras, 2006; Gadbury, 1975).

With an understanding of the impact of shifting nutritive values of the sward throughout depletion and their association with cow paddock access timing, cows could be differentially offered supplements based on milking order and the associated nutritive value of pasture to increase milk production and or productivity.

Conclusion

The association between milking order and paddock access, and the effects of pasture depletion on the shifting nutritive values over the duration of first and last cows accessing the pasture were determined. These data showed that paddock access order could be determined from milking order and CP, NDF and ADF ranged markedly throughout the duration of cows entering the paddock. Further analysis will be conducted on the association of paddock access order and milk production, with preliminary findings suggesting there is an opportunity to differentially feed supplements based on milking order and the nutritive value of pasture.

Acknowledgements

The authors would like to acknowledge the support of the Dairy Research Foundation, SCR and the investors of the Future Dairy project;

Dairy Australia, NSW Department of Primary Industries, University of Sydney and DeLaval. We are grateful to Mr. Kim McKean for assistance in herd management throughout the trial period.

References

Botheras, N. (2006). *The behaviour and welfare of grazing dairy cows (Bos Taurus): Effects of time away from pasture and position in the milking order.* University of Melbourne.

Delagarde, R., Peyraud, J. L., Delaby, L., & Faverdin, P. (2000). Vertical distribution of biomass, chemical composition and pepsin—cellulase digestibility in a perennial ryegrass sward: interaction with month of year, regrowth age and time of day. *Animal Feed Science and Technology, 84*(1), 49-68.

Gadbury, J. C. (1975). Some preliminary field observations on the order of entry of cows into herringbone parlours. *Applied Animal Ethology, 1*(3), 275-281.

Jouven, M. C., P. Baumont, R. (2006). Model predicting dynamics of biomass, structure and digestibility of herbage in managed permanent pastures. *Grass and Forage Science, 61*(2), 112-124.

Reeves, M., Fulkerson, W., & Kellaway, R. (1996). Forage quality of kikuyu (<I>Pennisetum clandestinum</I>): the effect of time of defoliation and nitrogen fertiliser application and in comparison with perennial ryegrass (<I>Lolium perenne</I>). *Australian Journal of Agricultural Research, 47*(8), 1349-1359.

Wade, M. H., & Carvalho, P. F. (2000). Defoliation patterns and herbage intake in grazed pastures *Ecophysiology of Grasslands and the Ecology of Grazing* (pp. 233-248): CAB International.

DETERMINING THE SAFETY AND LIKELY WITHHOLDING PERIOD OF A NEW INTRAMAMMARY MASTITIS THERAPY

P.T. Eats[AC], and K.R. Petrovski[B]

[AC]*University of Adelaide, Roseworthy campus, South Australia, 5371*
[B]*University of Adelaide, Roseworthy campus, South Australia, 5371*
[C]*Corresponding author. Email: patricia.eats@adelaide.edu.au*

Abstract

The study aim was to indicate the safety and elimination rate of a new antimicrobial compound (LP1369), which is intended as an intramammary treatment for mastitis. Eleven healthy cows were treated by intramammary route on one occasion with one syringe per quarter containing LP1369 in various formulations. Product safety was indicated when no change to cow health, udder health or milk health was noted via a range of appropriate observations. High Pressure Liquid Chromatography (HPLC) on milk samples tested the rate of elimination in milk. Average milk yield decreased mildly (from total yield 8.8L/cow to 7.0L/cow) and recovered within 4 days of treatment. Somatic cell count (SCC) increased sharply after treatment, as has been observed with commercially available treatments. The peak was at 24 hours following treatment followed by rapid decline and returned to normal by 10th milking after treatment. Most other observations showed no significant change. HPLC analysis showed concentration had reduced below the chemical residue limit within 48 to 72 hours of treatment. No significant changes to cow health were seen, suggesting the product is safe. Preliminary pharmacokinetic evaluation shows that elimination of LP1369 in milk is similar to currently commercially available mastitis products. In conclusion, LP1369 is indicated to be a good candidate for further investigation as a new intramammary antimicrobial therapy for mastitis. Additional investigation of ability to resolve mastitis incidence in-cow and further study of drug metabolism and elimination are suggested. Potential registration and commercial release of a new intramammary mastitis therapy may result.

Introduction

The dairy industry and other animal production industries face daily consumer inquiry about the use of antibiotics and its potential effect on human pathogen antibiotic resistance. Mastitis cases have a high rate of occurrence and necessarily consume a significant proportion of antibiotics, despite focused attempts at improvement of mastitis management. Whilst Countdown Downunder (Brightling *et al*., 1998) delivered sound new advice and structure to the way mastitis is managed on Australian farms, there is still much room for improvement of treatment outcomes and lowering its occurrence.

Mastitis remains a cause of significant financial, management, animal welfare and productivity costs to dairy farms. It is a source of frustration and stress to people working at all levels within a dairy business. Treatment failure is increasingly common, yet currently available therapies have not been re-evaluated since their market entry – in some cases decades ago. Modern dairy cows produce more milk and live under different management systems than those used in the era of testing of most products. The emergence of antibiotic-resistant, mastitis causing organisms is an additional fear, due to repetitive usage of chosen antibiotics on any given farm.

To date, the reported occurrence of antibiotic-resistant mastitis is low (Oliver *et al*., 2011, Petrovski *et al*., 2011), but recent, Australian studies are lacking.

Australian dairy farmers have a significant handicap with the number of mastitis therapy options available, in comparison to New Zealand counterparts. However, a global call has gone out to the research community, urging for development of new antimicrobial therapies (Spellberg *et al*., 2008), from which mastitis therapy development is poised to benefit. Development of new therapy alternatives would increase the arsenal of 'weapons' available to farmers, potentially increasing cure rates and decreasing threat of antimicrobial resistance. The combined weight of human and animal antimicrobial resistance fears and the lack of recent development of new pharmaceutical therapies for mastitis taper toward one inevitable conclusion – new therapies must be researched and developed.

One pharmaceutical company, Luoda Pharma (Caringbah, NSW) has risen to this call, leading to the engagement of the University of Adelaide's Roseworthy-based microbiological research unit. Within the microbiology laboratories at the University of Adelaide, one Luoda Pharma compound, LP1369, has shown promise as a potential mastitis therapy. The requirements for LP1369's candidature include that it inhibited the major local mastitis pathogens and did not damage animal cells in the laboratory setting. As a result, a proposal was made that testing the compound in live; healthy cows should be undertaken, to determine if LP1369 is truly safe for use in the sensitive mammary gland of a lactating dairy cow.

Additionally, the considerable financial cost of drug development prompted evaluation of whether a potential LP1369-containing product would be commercially competitive. If withholding period is determined to be greater than currently available therapy options, the product would be an unattractive choice to farmers. Thereby, no return on investment for the research sponsors would be likely. As a result, this study was designed to evaluate if LP1369 is safe as an intramammary treatment, and to test its rate of elimination from the cow in milk.

Materials and Methods

Eleven Holstein cows were purchased from a local commercial dairy. Health criteria were applied to selection of cows, including no somatic cell counts above 200,000cells/mL in the previous 12 months, four healthy quarters, and no antibiotic treatments in the previous month. Summary statistics of cow information at study entry are shown in Table 1.

Table 1. Cow (*n=11*) age, lactation and yield summary based at study enrolment in October 2013.

	Average	Median	Minimum	Maximum	Standard Deviation
Age (months	70.25	66.50	33.50	101.50	24.46
Lactation number	3.17	2.50	1.00	6.00	2.04
Days in Milk	347.08	311.50	93.00	601.00	209.15
Average daily yield (L)	23.55	22.25	14.70	40.80	7.36

Cows were housed at the research dairy facility, at the Roseworthy campus, The University of Adelaide, kept in industry-standard, dry-land, feed-lot conditions. This included maintenance on the fresh, total mixed ration (TMR) from the farm of cow origin. Cows were milked twice per day on one side of a 14-unit herringbone dairy with portable, DaviesWay, 2-unit milking machines.

Thermal image, somatic cell count, milk yield and body temperature were measured routinely throughout the duration of the pre-study and study period. The study observation period was 180 hours, with routinely collected data from the pre-study period serving as an historical baseline reference for each cow.

Four treatments were used in the study, with one formulation per treatment group. Treatments featured the same sized dose of LP1369 in suspension in formulation with the vehicle base. Formula 1 and two differed by compound particle size, while formula 3 incorporated the same dose size of finer milled grade of LP1369 with the addition of a solubility optimising agent. A control treatment consisted of the base vehicle with no LP1369 or solubility optimising agent.

On the first day of each study, all cows had aseptic milk samples collected for microbiological culture from each quarter, prior to milking. Cows were milked and the treatment protocol was then initiated.

After milking, one 'pilot' cow from each treatment group was treated with formulation 1, 2, 3 or the control formulation. One syringe per quarter was administered in all four quarters on one occasion. Pilot cows were monitored for two hours after treatment for signs indicative of negative impact of treatment, and were then reviewed at milking, 12 hours later. In the event of no indication of negative effect, the remaining cows of each treatment group were treated 24 hours after the pilot cow.

Observations performed prior to treatment and at each milking thereon focused on cow, quarter and milk changes. Cows were individually scored for lameness, inability to stand and signs of depression. Thermal images of udders were taken. Milk samples were collected to test for the presence and concentration of LP1369 and other inhibitory substances, using High Precision Liquid Chromatography (HPLC) and Delvotest.

Milk samples were also submitted for somatic cell count (SCC) analysis. Visual milk quality score, milk yield, body temperature and udder palpation score were recorded. Udder palpations were performed by the same technician at each milking. The technician who performed palpations was trained by the principal investigator, a veterinarian with significant experience in development of new mastitis therapies. Quality-checking of palpation accuracy occurred at random times throughout both studies, with a high level of congruence between 'palpators' throughout.

In the absence of indications of adverse effect in pilot cows after 24 hours, the remaining cows in each treatment group were treated (after milking) with the designated formulation. Any incidence of significant adverse effects in a pilot cow resulted in substitution with a reserve formulation. The same treatment dosage regimen and observation protocols were undertaken as for the pilot study cows. Observations continued to be recorded for all cows for 180 hours (8 days) after treatment.

Results

Target animal safety

Milk yield was recorded at 12 hour intervals, with morning milkings commonly featuring higher yields per cow. Table 2 shows yield depression of 34.9% and 28.7% for formulations 1 and 2 respectively (2 to 4L loss), coinciding with the 4th milking after treatment. Treatment with formulation 3 resulted in an 80% yield depression (from 5L to 1L), immediately after treatment. Yield peaks above pre-treatment yield were also observed during the study, with formulations 1 and 2 showing yield increase of 4.2% and 25.2% in milkings 5 and 6 respectively.

The pilot cow which received Formula 3 did not return to Time 0 yield during the observation period.

Average milk yield of each treatment group throughout the study period is charted in Figure 1. Alternating yield peak and trough patterns are associated with normal morning versus evening yield variation, with even-numbered milkings representing morning milkings.

Table 2. Yield high and low points throughout the study observation period with cross reference to yield at time 0, prior to commencement of the treatment protocol with experimental LP1369-containing intramammary formulations and control formulation.

	Time 0	Yield low (L)	Low milking no.	% difference (-)
Tmt 1	10.75	7.00	4.00	34.88
Tmt 2	10.38	7.40	4.00	28.71
Tmt 3	5.00	1.00	1.00	80.00
Control	8.50	6.50	11.00	23.53
	Time 0	Yield high (L)	High milking no.	% difference (+)
Tmt 1	10.75	11.20	5.00	4.19
Tmt 2	10.38	13.00	6.00	25.24
Tmt 3	5.00	4.50	2.00	-10.00
Control	8.50	9.00	5.00	5.88

Table 3: Summary of averaged highest and lowest somatic cell count in thousands per mL per treatment group, showing the milking number associated with the high or low. Values were taken during the study of intramammary treatment with LP1369-containing formulations and control formulation.

	Time 0	Highest SCC	High SCC milking
Tmt 1	233	2238	1
Tmt 2	196	2228	1
Tmt 3	607	3975	2
Control	248	869	6
	Time 0	Lowest SCC	Low SCC milking
Tmt 1	233	225	14
Tmt 2	196	200	14
Tmt 3	607	613	12
Control	248	217	14

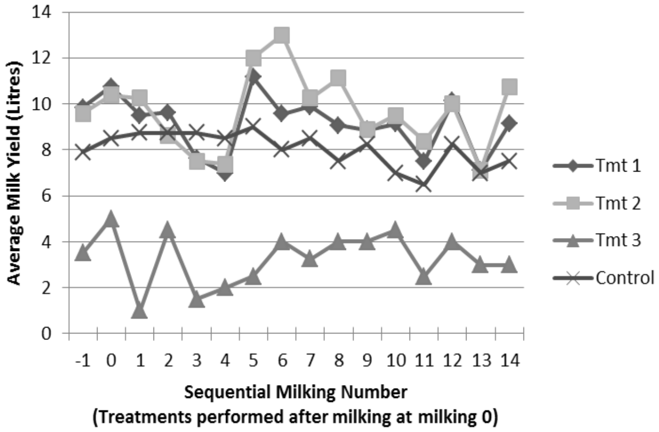


Figure 1. Milk yield progression during the course of the LP1369 intramammary formulation study, showing averaged yield per group from -1 until +14 milkings from treatment.

Somatic cell count was tested by National Herd Development in Cohuna, Victoria. The response to all treatments (including control) was a sharp increase at milking 1 (Figure 2). Treatment 3 SCC peaked at 3,975cells x10^3 /mL. Treatment with formulation 1 and 2 showed similar responses, with peak around 2,250 x10^3 cells/mL. All treatment groups had returned below 1,000 x10^3 cells/mL by the ninth milking post treatment, and to baseline by milking 14 (Table 3).

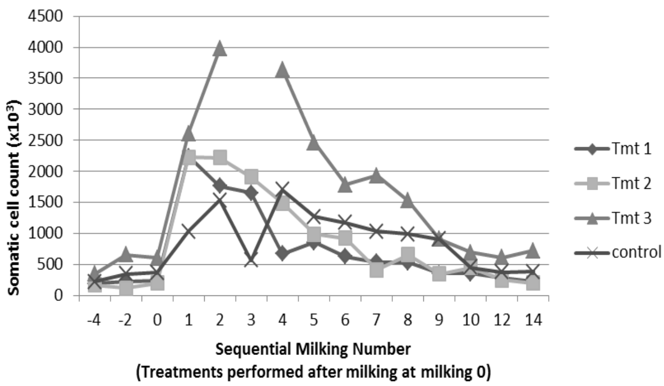


Figure 2. Somatic cell count, averaged per treatment group between -4 to +14 milkings from treatment with LP1369 in intramammary formulation.

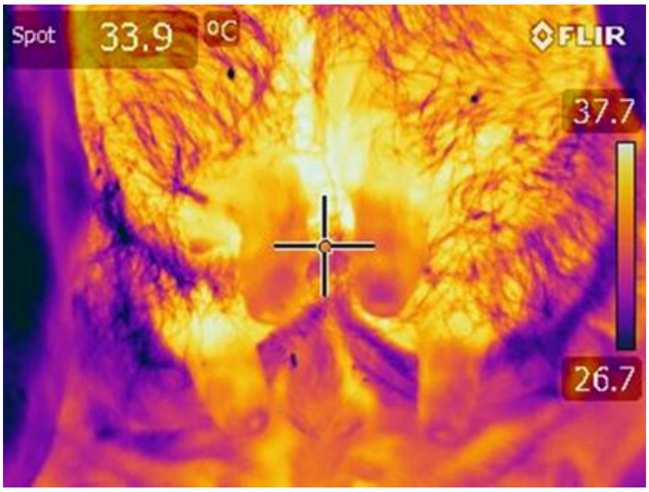


Figure 3, Thermographic image of a cow treated 12hrs earlier with experimental formulation 1, containing LP1369.

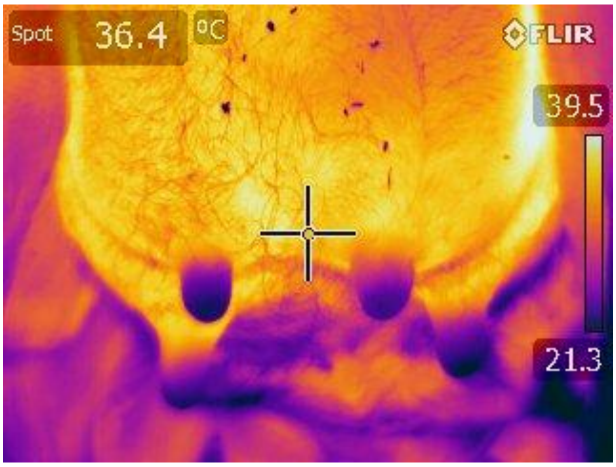


Figure 4. Thermographic image of the pilot cow treated with experimental formulation 3, containing LP1369 and a formulation optimising ingredient.

A number of thermographic images recorded prior to treatment for each cow were contrasted against images recorded at milkings after treatment of all cows (Figures 3 & 4). Formulations 1, 2 and the control showed no significant variation, but formulation 3 was associated with generalised skin temperature increase. This was corroborated by rectal temperature observations taken concurrently, which are not presented.

Withholding period

Residue of LP1369 in milk was quantified with HPLC analysis. HPLC testing was performed at the University of South Australia's pharmacology department. Depletion of chemical concentration in milk was shown to reach safe limits between 48 and 72hours after treatment. Depletion pattern was linear. Results were consistent between formulations 1 and 2, and as such, only the formulation 1 elimination kinetic regression is presented in Figure 5.

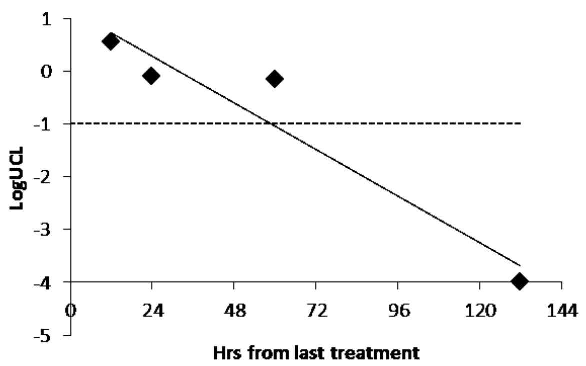


Figure 5. Linear regression of detected concentrations of LP1369 in treatment 2, taken from HPLC analysis data. Data was log transformed, logged upper confidence limit is modelled. Results are indicated over time from treatment (time 0) until time 144hours after treatment.

Discussion

The study aim of indicating safety and suitability of the rate of elimination of LP1369 compound in intramammary formulation was achieved. The successful completion of this study paves the way for further development of the LP1369 compound as a potential new intramammary treatment for mastitis.

Support for the hypothesised absence of significant irritation resulting from the intramammary treatment containing LP1369 is apparent for all treatments except formulation 3. It is concluded that at the concentrations and volumes used in this study, the LP1369 compound appears to be safe to cows when administered as an intramammary formulation.

Withholding periods for LP1369 were hypothesised to be no different to currently available intramammary therapy products. Indications from the preliminary analysis of HPLC results indicate LP1369 may in essence have a shorter withholding recommendation than current, commercially available mastitis therapy options, at the dosage rate trialed. LP1369 is therefore likely to be competitive with currently available mastitis therapies.

The current study's design incorporated observations of effects of treatment on the cow, the udder quarters and the milk. Results presented herein focus on milk parameters as these are highly volatile indications of impact on udder and cow health. The intended purpose was to highlight the effects of treatments in the most dramatic way.

Future studies will exclude the optimisation additive as a result of this study. The indications of negative effects attributable to the product can be concluded to be adequate justification for discontinuation of its incorporation in any further investigational formulations.

In conclusion, further formulation refinement and in-cow studies of LP1369 are required, before commercial registration is possible. These include efficacy studies in cows with mastitis, dosage determination studies, and a range of additional safety and pharmacokinetic evaluations to determine how the LP1369 compound is distributed, metabolised and excreted from the lactating dairy cow.

Acknowledgements

This work was commissioned and funded by Luoda Pharma, Caringbah, NSW.

The authors are grateful to the farm owners for their cooperation, The University of Adelaide for provision of space and facilities. Special thanks go to Kath Bryce at the Roseworthy TSU, Mandy Carr at the Production Animal Clinic, Hui San Wong from the microbiology department, and to all others from staff at the University of Adelaide's Roseworthy campus that have assisted in so many ways.

References

Brightling, P. B., G. A. Mein, A. F. Hope, J. Malmo, and D. P. Ryan. 1998. Countdown Downunder; Technotes for mastitis control. Dairy Research and Development Corporation.

Oliver, S. P., S. E. Murinda, and B. M. Jayarao. 2011. Impact of antibiotic use on resistance of vet & human pathogens. Foodborne Pathog Dis 8(3):337

Petrovski, K. R., R. A. Laven, and N. Lopez-Villalobos. 2011. Antimicrobial susceptibility of mastitis-causing bacteria (2003-2006). New Zealand veterinary journal 59(2):59.

Spellberg, B., R. Guidos, D. Gilbert, J. Bradley, H. W. Boucher, W. M. Scheld, J. G. Bartlett, J. Edwards, Jr., and A. Infectious Diseases Society of. 2008. Antibiotic-resistant infections: a call to action... Clinical infectious diseases : an official publication of the Infectious Diseases Society of America 46(2):155

ANTHELMINTIC RESISTANCE ON MACALISTER IRRIGATION DISTRICT DAIRY FARMS

S.L. Bullen[ABC]

[A]University of Melbourne, Werribee, Victoria, 3030
[B]Maffra Veterinary Centre, Maffra, Victoria 3860
[C]Email: bullens@student.unimelb.edu.au

Abstract

The aim of this study was to determine the prevalence of gastrointestinal nematode resistance to macrocyclic lactone (ML), benzimidazole (BZ) and levamisole (LV) anthelmintics on 16 commercial dairy farms in the Macalister Irrigation District (MID) of south-east Victoria. Faecal egg count reduction tests (FECRTs) were conducted between May 2013 and March 2014.

Resistance was reported if there was <95% reduction in faecal egg count (FEC) 10-14 days post treatment. Of the farms tested 16/16 (100%) had evidence of anthelmintic resistance in at least one species. Of particular concern is the detection of highly pathogenic Ostertagia spp. resistant to all three available classes on 3/16 (19%) farms. The results of this study suggest that current nematode control strategies are unlikely to be sustainable into the future and highlight the need for greater awareness amongst dairy farmers with regard to preserving the longevity of current and future anthelmintics.

Introduction

The consequences of gastrointestinal nematode parasites on pasture-based dairy herd productivity are well recognized worldwide (Lean, Westwood, & Playford, 2008). Numerous studies have demonstrated the negative correlation between parasite infestations and milk production in adult dairy cows both in terms of milk volume and milk solids (Gross, Ryan, & Ploeger, 1999; Sanchez, Dohoo, Carrier, & DesCoteaux, 2004). In addition, adequate parasite control is one of the most important factors in achieving adequate live weight gain of replacement heifers. Mejia *et al*. (2009) found that failure to control gastrointestinal nematodes prior to first oestrus resulted in significantly higher culling rates in dairy heifers following their first lactation due to permanent growth deficits. The management of replacement heifers such as early weaning, rearing of successive groups of heifers on the same area of pasture and limited land availability for heifer rearing due to Bovine Johne's Disease control programs means that frequent drenching is often the only means available to farmers to control parasitism (Parkinson, Vermunt, & Malmo, 2010). However, heavy reliance upon anthelmintics in beef cattle and other livestock has led to widespread reports of resistance to all available classes of anthelmintics in most economically important parasite species (Sutherland & Leathwick, 2011).

Prior to this study, the only published case of anthelmintic resistance on Australian dairy farms involved subtropical *Haemonchus placei* and *Cooperia* spp. on two properties in south-eastern Queensland following long-term fortnightly macrocyclic-lactone (ML) anthelmintic treatments to control cattle tick (*Rhipicephalis microplus*) (Lyndal-Murphy, Rogers, Ehrlich, James, & Pepper, 2010). The aim of this study was to determine the prevalence of resistance to ML, benzimidazole (BZ) and levamisole (LV) anthelmintics on dairy farms in the Macalister Irrigation District (MID) of south-eastern Victoria.

Materials and methods

Sixteen commercial dairy farms in the MID were enrolled in this study based on willingness to participate and a minimum of 60 4-8 month old replacement heifers which had not been drenched in the preceding 42 days. For each farm, information was obtained about the herd (milking herd size, calving pattern, number of replacements reared and introductions) and previous anthelmintic usage (farmer perceptions, drenching policies, anthelmintic types).

FECRTs were conducted according to the World Association for the Advancement of Veterinary Parasitology (WAAVP) guidelines between May 2013 and March 2014 at the time when mean FEC rose above 150eggs/g (Coles *et al.*, 1992). Heifers were weighed and randomly allocated to one of four treatment groups as follows (1) ML - doromectin 0.2mg/kg via subcutaneous injection (Dectomax®, Zoetis Australia), (2) BZ - fenbendazole 7.5mg/kg orally (Panacur 100®, MSD Animal Health Australia), (3) LV - levamisole hydrochloride 8mg/kg orally (Nilverm LV®, MSD Animal Health Australia) and (4) untreated control. Each group comprised 15 animals and anthelmintics were administered by the investigator using calibrated drench guns.

Individual faecal samples were collected from the rectum of each heifer 10-14 days later and submitted to Dawbuts Pty Ltd (Camden, N.S.W., Australia) for parasitological examination. At the laboratory, individual FECs were conducted using a Modified McMaster method where one egg counted represented 25eggs/g. In addition, equal amounts of faeces from each sample were pooled for larval culture and morphological speciation for each treatment group.

Calculations were carried out using the 'RESO' FECRT analysis program whereby the arithmetic mean FEC for each treatment group was compared with the untreated control 10-14 days post treatment (Coles *et al*., 1992).

Resistance was defined as <95% reduction in FEC. Results for particular nematode genera (*Ostertagia*, *Trichostrongylus* and *Cooperia*) were considered inconclusive if the differentiated FEC (apportioned according to the percentage of larvae cultured) of the control group was less than 25eggs/g.

Results

Farm sizes ranged from 180 to 600 milking cows (mean 400) and the number of replacements reared ranged from 55-200 (mean 103). 6/16 (38%) of farms were spring calving herds whilst all others were split (autumn/spring).

All farmers had routinely used ML anthelmintics on both replacement heifers and the milking herd in the past 3 years. 11/16 (69%) had used BZ anthelmintics on replacement heifers and 8/16 (50%) had used them on the milking herd and no farmers had used LV anthelmintics in the past 3 years.

There were only two completely closed herds. The others mostly brought lease bulls onto the property but some had purchased cows. Of those, 2/14 (14%) administered a 'quarantine' drench on arrival consisting only of a single-active anthelmintic. 3/16

(19%) farmers did not consider anthelmintic resistance to be an existing or emerging threat on their farm.

The prevalence of resistance for each anthelmintic class is presented in Table 1. Reduction in undifferentiated FEC >95% for all three anthelmintics tested only occurred on 1/16 (6%) farms; however, upon differentiation of FEC by nematode genera this property was found to have fenbendazole resistant *Ostertagia* spp.

Resistance to both doromectin and fenbendazole was detected on 7/16 (44%) farms and resistance to all three classes was detected on 3/16 (18%) of farms.

On the properties tested, fenbendazole had poor efficacy (FECR) against *Ostertagia* spp. and *Trichostrongylus* spp. with 34% being the lowest reduction recorded for *Ostertagia* spp. on one farm. In addition, on 3/11 (27%) farms none of the three actives achieved >95% FECR for *Ostertagia* spp.

Table 1. Prevalence of anthelmintic resistance in undifferentiated faecal egg count reduction (FECR) tests

Active (class)	# farms tested	# farms with <95% FECR	% farms with <95% FECR
Doromectin (ML)	16	11	69
Fenbendazole (BZ)	16	11	69
Levamisole (LV)	16	5	31

Table 2. Prevalence of anthelmintic resistance by nematode genera from differentiated faecal egg count reduction (FECR) tests

Active (class)	Parasite genus	# farms with >25 eggs/g	# farms with <95% FECR	% farms with <95% FECR
Dor (ML)	*Ostertagia*	11	3	27
Dor (ML)	*Tricho-strongylus*	4	1	25
Dor (ML)	*Cooperia*	16	10	63
Fen (BZ)	*Ostertagia*	11	9	82
Fen (BZ)	*Tricho-strongylus*	4	4	100
Fen (BZ)	*Cooperia*	16	6	38
Lev (LV)	*Ostertagia*	11	4	36
Lev (LV)	*Tricho-strongylus*	4	2	50
Lev (LV)	*Cooperia*	16	0	0

Dor = Doromectin; Fen = Fenbendazole;
Lev = Levamisole

Discussion

The results demonstrate a high level of anthelmintic resistance in gastrointestinal nematode parasites on the 16 Macalister Irrigation District dairy farms involved in this study with 94% of farms failing to achieve a >95% reduction in undifferentiated FEC for at least one anthelmintic class. These results are similar to recent findings on beef cattle properties in south-west Victoria and the North Island of New Zealand (Rendell, 2010; Waghorn *et al*., 2006).

The market for anthelmintics in cattle has been dominated by the MLs since their introduction in the 1980s (Sutherland & Leathwick, 2011). In this study, resistance to the MLs occurred primarily in *Cooperia* spp. which is generally considered less pathogenic than *Ostertagia* spp. or *Trichostrongylus* spp.

Reports of ML-resistant *Cooperia* spp. are common in the literature and this is one of the proposed reasons why anthelmintic resistance in cattle has been given little importance until now (Kaplan, 2004). However, a recent study involving experimental infection with a pure culture of ML-resistant isolate of *Cooperia punctata* demonstrated a significant effect on live weight gain and feed intake in the absence of clinical signs of parasitism (Stromberg *et al*., 2012). This suggests that the production effect of failing to control ML-resistant *Cooperia* spp. warrants further investigation.

The high level of BZ-resistant *Ostertagia* (82%) and *Trichostrongylus* spp. (100%) and widespread use of BZ anthelmintics in both replacement heifers and the milking herd suggests that many of the farmers involved in this study are using products which are not fully effective. Although there were fewer cases of ML-resistant *Ostertagia* spp. (27%), on each farm where doromectin failed the other two actives also failed. The high pathogenicity of both species in cattle is of concern. At low levels they may cause substantial production losses both in terms of milk production and live weight gain but in stressed or heavily burdened animals they have the propensity to cause substantial clinical disease and death if not adequately controlled (Parkinson *et al*., 2010).

Two out of fourteen (14%) farmers who brought cattle onto the property administered a single-active ML or BZ drench which is unlikely to constitute an effective quarantine drench due to the high levels of ML-resistant *Cooperia* spp. and BZ- resistant *Ostertagia* spp. detected in this study. In such situations, the use of a combination anthelmintic which contains two or more classes of anthelmintic with differing activity but a similar spectrum of activity would be preferential. However, there are currently no combination products registered for use in dairy cattle in Australia.

This is disappointing given that their use has also been advocated in the face of existing anthelmintic resistance and has been shown to be more effective at slowing the development of resistance than rotation of drench classes (Bartram, 2012).

The presence of *Ostertagia* spp. resistant to all three currently available drench classes on 3 farms highlights an urgent need for the development and registration of either a novel action anthelmintic class or combination products for use in dairy cattle.

3/16 (19%) farmers did not consider anthelmintic resistance to be an existing or emerging threat on their farm.

However, the results of this study highlight the need for greater awareness amongst dairy farmers with regard to both testing for anthelmintic resistance and adopting sustainable parasite control measures which preserve the longevity of existing and future anthelmintics.

Acknowledgements

This work was supported by the Maffra Veterinary Centre and those farmers who contributed their time and livestock to the study. Zoetis and Steinfort AgVet donated products. The staff at Dawbuts Pty Ltd conducted faecal egg counts, larval culture and morphological speciation. Valuable on-farm technical assistance was provided by Dean Rowley. Additional assistance was provided by Dr Matthew

Playford, Dr Neil Charman and supervisors Dr Michael Pyman, Dr Peter Mansell, Dr David Beggs and Dr Duncan Runciman. This project was jointly funded by GippsDairy and Rural Finance. The residency program for which this research was conducted is funded by Dairy Australia and The Gardiner Foundation.

References

Bartram D. (2012). Small Ruminant Res. 110, 96.

Coles G. C., Bauer C., Borgsteede F. H., Geerts S., Klei T. R., Taylor M. A. and Waller P. J. (1992). Vet. Parasitol. 44(1-2), 35.

Gross S. J., Ryan W. G. and Ploeger H. W. (1999). Vet. Rec. 144(21), 581.

Kaplan R. M. (2004). Trends Parasitol. 20(10), 477.

Lean I., Westwood C. and Playford M. (2008). NZ. Vet. J. 56(6), 261.

Lyndal-Murphy M., Rogers D., Ehrlich W. K., James P. J. and Pepper P. M. (2010). Vet. Parasitol. 168(1-2), 146.

Mejia M.E., Perri A.F., Miglierina N., Formina N., Becu-Villalobos D. and Lacau-Mengido I.M. (2009). Vet. Rec. 165, 143.

Parkinson T. J., Vermunt J. J. and Malmo, J. (2010). "Diseases of Cattle in Australasia", (New Zealand Veterinary Association Foundation for Continuing Education: Wellington).

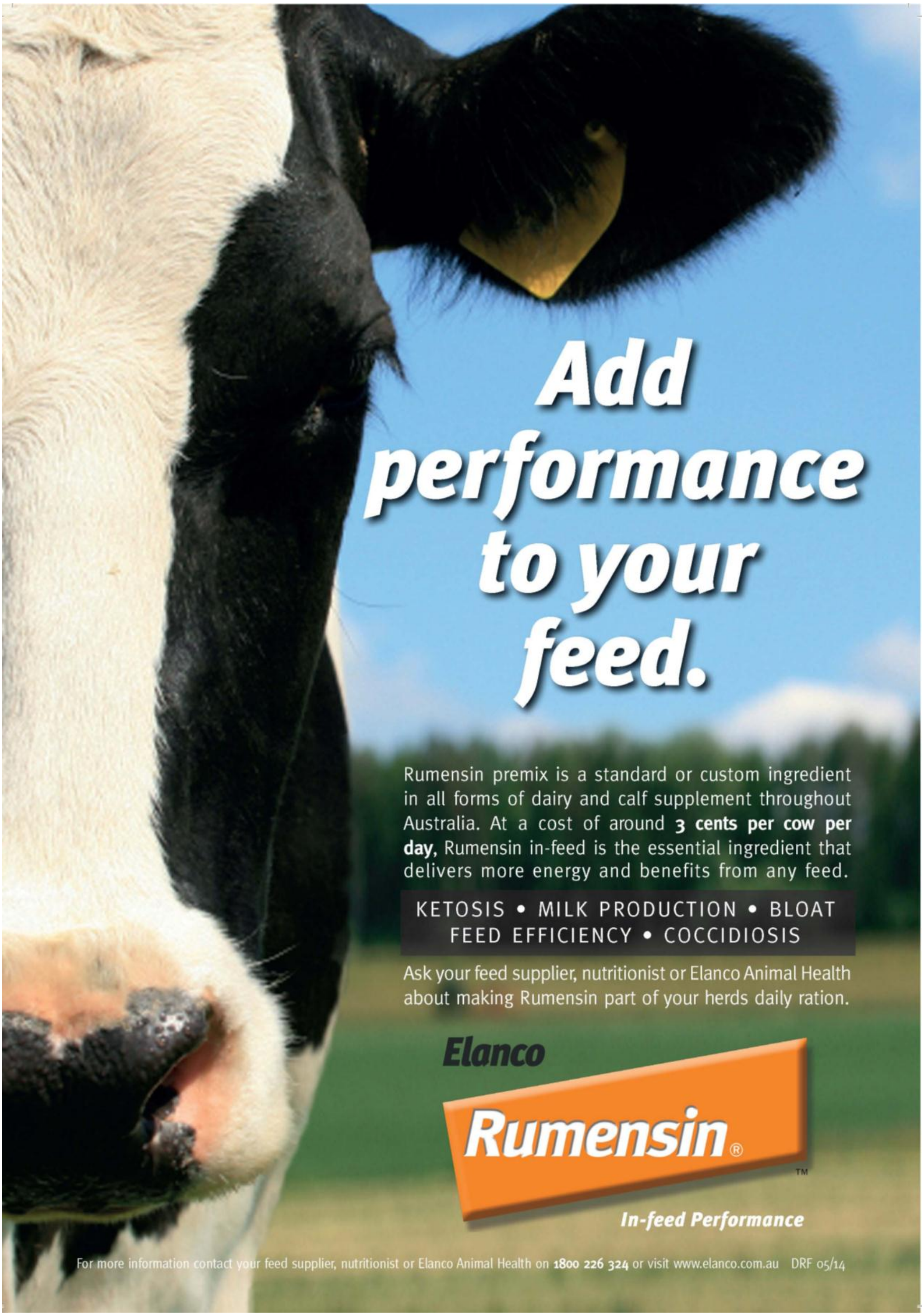
Rendell D. K. (2010). Aust. Vet. J. 88(12), 504.

Sanchez J., Dohoo I., Carrier J. and DesCoteaux L. (2004). 63(3-4), 237.

Stromberg B. E., Gasbarre L. C., Waite A., Bechtol D. T., Brown M. S., Robinson N. A. and Newcomb H. (2012). Vet. Parasitol. 183(3), 284.

Sutherland I. A. and Leathwick, D. M. (2011). Trends Parasitol. 27(4), 176.

Waghorn T. S., Leathwick D. M., Rhodes A. P., Jackson R., Pomroy W. E., West D. M. and Moffat J. R. (2006). NZ. Vet. J. 54(6), 278.


Add performance to your feed.
Rumensin premix is a standard or custom ingredient in all forms of dairy and calf supplement throughout Australia. At a cost of around **3 cents per cow per day,** Rumensin in-feed is the essential ingredient that delivers more energy and benefits from any feed.
KETOSIS • MILK PRODUCTION • BLOAT
FEED EFFICIENCY • COCCIDIOSIS
Ask your feed supplier, nutritionist or Elanco Animal Health about making Rumensin part of your herds daily ration.
Elanco
Rumensin®
TM
In-feed Performance
For more information contact your feed supplier, nutritionist or Elanco Animal Health on 1800 226 324 or visit www.elanco.com.au DRF 05/14

RUMINATION PATTERNS AND LOCOMOTION ACTIVITY IN A DAIRY COW DIAGNOSED WITH LEFT DISPLACED ABOMASUM (LDA): A CASE REPORT

S. Talukder[A, C], K. L. Kerrisk[A], C. E. F. Clark[A], S. C. Garcia[A] and P. Celi[A, B]

[A]*Dairy Science Group, Faculty of Veterinary Science, The University of Sydney, Camden (2570), NSW, Australia*
[B]*Melbourne School of Land and Environment, The University of Melbourne, Parkville (3010), Victoria, Australia*

[C]*Corresponding author. Email: stal8977@uni.sydney.edu.au*

Abstract

Left displaced abomasum is an economically important problem of dairy cattle in early lactation which interferes with feed intakes, digestion and milk production. This study describes the rumination and activity pattern of a cow that developed a left displaced abomasum (LDA). Thirty cows were fitted with SCR HR Tags attached to neck collars which continuously monitored individual cow activity and rumination and reported these for 2-h intervals. Of the 30 cows, one was diagnosed for LDA based on the clinical symptoms. A decreasing trend of weighted rumination change was observed from day -6 to the day of diagnosis in the LDA cow followed by an upward trend during the postoperative period. Early detection of an LDA (if followed by prompt intervention) may result in improvements in animal well-being and recovery speed.

Introduction

Left displaced abomasum (LDA) is an important metabolic disease in dairy cattle (Qu *et al* 2013) since when the cases have increased to 5% in postpartum dairy cows (Geishauser *et al* 2000) and the subsequent cost per case, including surgery, milk loss, and mortality is estimated to be between US$250 and US$400 (Bartlett *et al* 1995; Qu *et al* 2013). The occurrence of LDA is related with high dietary carbohydrates and concurrent diseases (mastitis and metritis) associated with endotoxaemia, decreased feed intake and consequently decreased rumen fill (Hasanpour *et al* 2011; Nebel 2014).

Due to increasing herd size and production per cow, the use of technology and sensors is becoming more prevalent in livestock farming (Maltz 2010). Increased public awareness for animal well-being enhances the technological progress and use of sensors to provide detailed real time data about the individual cow in the herd (Maltz 2010).

As a result of technical progress in the monitoring cows automatic detection systems have become a practical reality (Nebel 2014). With correct interpretation, this data can be translated into information to support decision making on the level of the individual cow (Maltz 2010). Currently, activity monitoring has been reported to be used for oestrus detection in dairy cows (Aungier *et al* 2012). So it might be possible to use the real time data recorded by the same device for management of reproduction and health issues in farms.

The diagnosis of a LDA is based on symptoms such as anorexia and decreased milk production and clinical examination by simultaneous auscultation (listening to the internal sound of the body) and percussion (tapping on a surface to determine the underlying structure). From an animal well-being perspective, early detection of any health problems would be desirable (Rutten *et al* 2013).

One possible method to identify potential health problems in dairy cows before they show clinical signs is to use an automated system that records the activity and rumination profiles of an individual cow (Edwards *et al* 2004).

A decrease in daily rumination along with a decrease in daily activity may provide an early warning to detect an LDA in dairy cows. Changes in rumination patterns seem to be related to health problems (Bar *et al* 2010); however, no studies have been conducted to determine the association between rumination patterns, locomotion activity and LDA. Therefore, the objective of this case report was to profile levels of rumination and activity associated with an LDA before diagnosis and after surgical correction.

Case description

Cow 1471 was one of the 30 cows that were enrolled in a trial for evaluating the potential of SCR HR LD Tags (SCR Engineers Ltd., Netanya, Israel) for oestrus detection. The study was conducted during October and November 2013 (spring) at the University of Sydney's Corstorphine dairy farm Camden, NSW, Australia. All cows were managed in a grazing system with pelleted concentrate (8 kg/cow/d) provided at milking. All experimental procedures were approved by the University of Sydney Animal Ethics Committee (N00/9-2012/1/5829). During the experimental period, all cows were fitted with SCR HR LD neck collars. The neck collar consisted of an accelerometer to quantify activity and a microphone to monitor rumination time (RT) (Bar *et al* 2010). The SCR collars were fitted 7 days before the start of the trial to establish a baseline threshold for activity and RT.

The device continuously monitored the individual cow activity and RT for 2 h time blocks, which were then downloaded to a farm computer and collated. An identification unit at the entrance of the milking parlour retrieved the data (via infrared communication) into a control unit (Aungier *et al* 2012).

The support software reported the rolling average 24-h period activity/rumination level relative to a normal baseline activity established for the previous 7-d average activity/RT level to identify the changes in activity/RT level (Aungier *et al* 2012).

Cow 1471 was a Holstein cow [Identification No. 1471; bodyweight 600 kg; age 3 years; days in milk 76] which had reduced milk production and reduced intake. She was diagnosed with a LDA by a veterinarian, based on auscultation of tympanic, resonant, high-toned ping between approximately the 9th and 13th ribs in the middle third (dorsoventrally).

The day when cow 1471 was diagnosed surgically corrected for LDA by right flank omentopexy was defined as day 0. Twenty four hour average weighted activity and RT during the period 10 days either side of day 0 was used to examine the changes of these profiles.

All data related to rumination and activity was compared to those of the 29 healthy cows. Levels are referred to as higher or lower if they are outside the confidence interval of healthy cows.

Results

Differences in RT of cow 1471 compared with that of her healthy herd mates are depicted in Figure 1. Cow 1471 presented variable RT. From day -10 to day -7, rumination time was higher while from d -6 to d 0, RT was lower compared to her healthy herd mates.

After day 0, an increase in RT time for cow 1471 was observed after which time, RT was similar to that observed for her herd mates (Figure 1).

The activity time of cow 1471 compared to her healthy herd mates is presented in Figure 2. Cow 1471 presented decreased activity time 3 days before the day of clinical diagnosis of LDA compared to that of her healthy counterparts.

After the LDA was surgically corrected (day 0), there was an increase in activity time for cow 1471 after which activity levels were similar to those of the healthy cows (Figure 2).

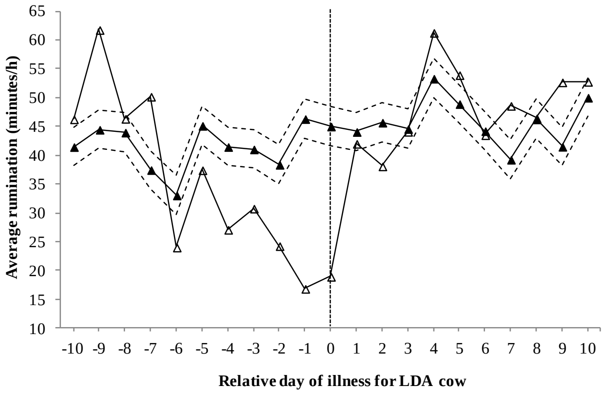


Figure 1. Average rumination time of LDA cow (Δ) and healthy cows (▲). The relative day of illness in X axis corresponds only for the LDA cow. The dashed lines indicate the limit of 95% confidence interval and the vertical dotted line indicates the day of clinical diagnosis of LDA

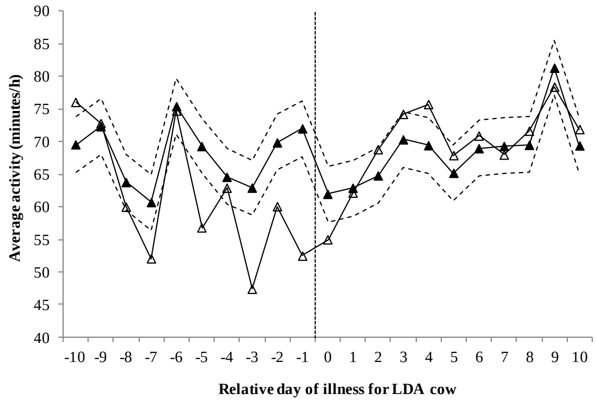


Figure 2. Average activity time of LDA cow (Δ) and healthy cows (▲). The relative day of illness in X axis corresponds only for the LDA cow. The dashed lines indicate the limit of 95% confidence interval and the vertical dotted line indicates the day of clinical diagnosis of LDA

Discussion

Based on the changes of the RT profiles, it might be possible to detect LDA in cow at least 5 to 6 days earlier than the actual date of clinical diagnosis. The LDA cow also presented a decrease in activity 3 days before the day of diagnosis.

During the surgical operation, Cow 1471 was also diagnosed with metritis. Cow 1471 presented decreased RT from d -6 to the day of diagnosis which might be due to abomasal enlargement and reduced rumen fill.

We observed a decrease in activity time 3 days before the day of clinical diagnosis of LDA compared to that of healthy cows. This finding differs from the findings of the previous study (Edwards *et al* 2004) which reported a higher activity in an LDA cow 1 d before clinical diagnosis and a spike in activity on d 0. Use of a large number of healthy (*n* = 567) and sick (*n* = 609) cows (all housed) for comparison of the activity level in that study compared to the pasture-based system in the present study may explain (at least in part) the discrepancy. The decreased activity in cow 1471 may have been attributed to a loss of appetite and reduced grazing time, restricted movements and spending more time lying down (Edwards *et al* 2004; Schultz 1988).

The SCR tags provided detailed real time data about the individual cow. The real time data may help to identify the individuals that deviate from 'normal' or from 'expected' levels of activity or rumination to determine which animals are outside the desired population confidence interval and hence can support management decision making at an individual cow level (Maltz 2010; Nebel 2014).

Adams *et al* (2013) have previously reported the use of sensor systems (pH of rumen fluid and temperature boluses) regarding metabolism, but these sensors provided the farmer with raw sensor data that are not related to clearly defined problems or actions (Rutten *et al* 2013). In addition, the temperature sensors are radio telemetric rumen boluses; that is, in-cow sensor (Rutten *et al* 2013) while accelerometer is attached to a neck collar and hence classified as on-cow sensor which might be more feasible to implement in farming conditions.

The present study describes the rumination and activity profiles for a single LDA case. Further detailed study comparing these profiles between a large number of healthy and LDA affected cows would be required to allow a full understanding of the impact of the condition on the profiles to be developed. It is also worthwhile to determine the efficiency of the alert produced by the SCR tag for early prediction of specific health conditions. In addition, developing detection models based on rumination behaviour might be warranted, as they can provide a real-time indication of the health status of the cow.

Conclusion

There were distinct differences between the RT and activity of healthy cows and the case study of LDA cow. Changes in rumination along with changes in activity might be beneficial for early prediction of LDA. This technology may help farmers for early prediction of disorders and reduce the associated treatment cost and milk yield loss. Further detailed studies regarding the sensitivity and specificity of this technique for early prediction of other metabolic or digestive disorders during the transition period might be warranted.

Acknowledgements

The authors would like to acknowledge the support of the Dairy Research Foundation, SCR and the investors of the Future Dairy project; Dairy Australia, NSW Department of Primary Industries, University of Sydney and DeLaval. We are grateful to Mr. Kim McKean for assistance in animal husbandry. The primary author has been supported by The University of Sydney International Postgraduate Research Scholarship.

References

Adams A.E., Olea-Popelka F.J. and Roman-Muniz I.N. (2013). J. Dairy Sci. 96, 1549.

Aungier S.P.M., Roche J.F., Sheehy M. and Crowe M.A. (2012). J. Dairy Sci. 95, 2452.

Bar D. and Solomon R. (2010). Proc. First North Am. Conf. Precis. Dairy Manag. 214.

Bartlett P.C., Kopcha M., Coe P.H., Ames N.K., Ruegg P.L. and Erskine R.J. (1995). J. Am. Vet. Med. Assoc. 206 (8), 1156.

Edwards J.L. and Tozer P.R. (2004). J. Dairy Sci. 87 (2), 524.

Geishauser T., Leslie K. and Duffield T. (2000). Bovine Pract. 34, 51.

Hasanpour A., Saranjam, N. and Amuoghli B.T. (2011). Glob. Vet. 7, 478.

Maltz E. (2010). Proc. First North Am. Conf. Precision Dairy Manag.

Nebel R.L. (2014). Dairy Cattle/Technical articles/Genetics - Reproduction (Retrieved 12.03.2014).

Qu Y., Lytle K., Traber M.G. and Bobe G. (2013). J. Dairy Sci. 96 (5), 3012.

Rutten C.J., Velthuis A.G.J., Steeneveld W. and Hogeveen H. (2013). J. Dairy Sci. 96 (4), 1928.

Schultz L.H. (1988). In “The Ruminant Animal: Digestive Physiology and Nutrition”, (Eds D. C. Church) p.493 (Prentice-Hall, Inc., Englewood Cliffs, NJ).

INVESTIGATION INTO THE CHALLENGES ASSOCIATED WITH REPRODUCTIVE MANAGEMENT ON COMMERCIAL DAIRY FARMS UTILIZING AUTOMATIC MILKING SYSTEMS

D. Keeper[AC], J. House[A], K. Kerrisk[B]

[A] University of Sydney, Livestock Veterinary Services, Brownlow Hill, N.S.W., 2570
[B] Dairy Science Group, Faculty of Veterinary Sciences, Camden (2570) N.S.W., 2570
[C] Corresponding author. Email: Derek.keeper@sydney.edu.au

Abstract

Automatic Milking Systems generally relies on voluntary 'trafficking' of the cows around the farm system to present themselves for milking. This study was designed to investigate the management strategies employed in Australian AMS dairies. In particular we were interested to develop an understanding of whether or not farmers are modifying their management practices either to cope with differences or challenges created by AMS or as a result of the fact that the milk harvesting process is now automated. For example, if farmers feel that detecting oestrus is real challenge with AMS and they have moved to predominantly natural mating to cope with this, it is important that we have an early warning of this so that it can be addressed at an industry level. A particular focus of the study was with respect to reproductive management, how well they perform, and determining what aspects of in which farmers perceived or were experiencing real challenges. The initial survey showed that much of the management strategies currently employed are similar to nearby conventional dairies.

Introduction

Automatic milking systems (AMS) were first introduced in the Netherlands in 1992, and were adopted predominantly for the benefits associated with labour and lifestyle (de Koning and Rodenburg 2004). However, saving labour associated with milk harvesting may or may not result in redeploying that labour to other aspects of the farm enterprise, including reproductive management (de Koning and Rodenburg 2004).

Cows in an AMS system present themselves to the milking unit voluntarily with varying frequency (de Koning 2010). The level of variation could significantly affect routine management tasks such as artificial insemination or synchronisation programs. Milking frequency is potentially another interesting and complicated issue, as it is variable (both within and between cows) in AMS herds.

It is also known that an increase in milking frequency can result in an increase in milk yields, however, whether increasing milk yields has a negative impact on reproductive performance is controversial and is expected to be related to the level of nutrition (amongst other factors) (Amos *et al*. 1985). To date there is insufficient knowledge to be sure of the effects the variability in milk yields and milking frequency will have on reproductive performance.

This study aims to investigate the reproductive management practices currently used in AMS dairies within Australia, determine how well these practices are working, and identify problem areas and cow groups to assist the industry in managing these issues. It will also look at technologies that are either available or currently in development that may assist in managing these issues.

Materials and methods

This study is divided into three phases. The first phase was a survey of AMS and surrounding conventional dairies. Questions were designed to examine a large scope of management areas, with specific focus on reproduction management practices. This was distributed in paper and online formats, using assistance from government and industry bodies to assist in distribution to conventional dairies near known AMS facilities.

Responses were collated and analysed using GenStat 16th Edition Version 16.1.0.10916 (VSN International Ltd copyright 2013). Regression, t-test, ANOVA, and Chi square analyses were conducted.

If expected values were less than 5, a random permutation test was run to verify the values. A statistically significant P value of 0.05 was chosen for all analyses.

The second phase involves quantitative evaluation of reproductive performance within AMS herds. The results will show current reproductive performance levels achieved in Australian AMS dairies, and highlight any problem areas or at risk cow groups. From these results it is hoped that extension articles can be developed with some best practice guidelines regarding reproductive performance. Downloading of data and computer programming for analysis is currently underway.

The results of these studies will be published in scientific journals and be presented to scientific audiences. They will also be used in the development of presentations and fact sheets for the dairy industry. Having these resources will assist producers in avoiding or dealing with the challenges that might arise with reproductive management of AMS cows, thereby making the transition to this technology more streamlined.

Results

The response rate for the survey was 32 conventional dairies, and 10 AMS, which amounted to 21% overall. AMS respondents tended to be younger, though not significantly. Similarly, milk production tended to be slightly higher in AMS dairies.

Size of dairies, both in terms of number of cows and physical area were not significantly different between respondents. Nor was use of external professionals as consultants, such as veterinarians, nutritionists, agronomists or herd consultants.

Calving patterns were similar between AMS and conventional, with a relatively even spread between year round, seasonal, and split calvings. Pedometers were used significantly more often in AMS for heat detection than in conventional dairies ($P<0.001$).

AMS farms using box type designs had an average of 3.4 boxes, milking an average of 266 cows, or 78 cows per unit.

Data for reproductive performance is currently being downloaded from four AMS farms. Initial reports are expected by the time of the conference.

Discussion

A response rate of 21% overall was excellent for a non-volunteer survey. AMS respondents tended to be younger, which may reflect great acceptance of technology amongst younger people, however this is contentious under current information technology acceptance theory (Workman 2014). It is possible that it was the youngest member of the enterprise that actually responded to the survey – particularly when there were multiple generations involved with the investment. However, other results from this survey show that respondents expressed a high level of concern regarding the lack of quality labour available in rural areas, which may have influenced the variation in age.

Milk yield was slightly higher in AMS farms, however, no questions were asked regarding milking frequency. Thus, it is unknown whether the average milking frequency of conventional dairies was comparable.

Responses between AMS and conventional farmers showed no significant differences in farm size, herd size, use of professional consultants, or calving patterns. This is encouraging as it is deemed important that key management decisions are driven by the farms business targets and are not significantly influenced simply by the fact that the cows are now milked by robots.

Pedometers were used significantly more frequently in AMS farms. Each of the systems currently available in Australia has a pedometer system or a more elaborate oestrus detection device as an option at installation, or which can be added to the system later. As cows are not observed at milking, allowing the robot to monitor activity levels, which can be a three to four fold increase, facilitates heat detection in this situation (Rorie *et al* 2002; Saint-Dizier and Chastant-Maillard 2012).

Number of cows per box of 78 is consistent with the suggested levels recommended by the manufacturers of AMS units. Further analysis is required to determine if this stocking level is the most economical for each farm (DeLaval, Lely and Insentec Australia websites).

Conclusions

AMS within Australia is still within its infancy. As such, there is still much to be learnt about best practice management options for successful adoption of robotic milking. However, this survey suggests that conventional practices are useful and effective, until more is realised about these systems. Already, there are a few changes that are being used more frequently and effectively, and this is likely to continue to expand.

Acknowledgements

The author would like to acknowledge the assistance and support provided by the Dairy Research Foundation, the University of Sydney Livestock Veterinary Services Unit and the investors of the FutureDairy project, DeLaval, NSW Department of Primary Industries, The University of Sydney and Dairy Australia. The author would also like to thank the AMS farmers in the data collection (who will remain anonymous) and the technical support provided by Lely, DeLaval and Insentec.

References

De Koning, K and Rodenburg, J (2004) *Automatic Milking: State of the Art in Europe and North America.* In A Better Understanding: Automatic Milking. Wageningen, the Netherlands, 27-37.

De Koning, C. J.A. M. (2010) *Automatic Milking – Common Practice on Dairy Farms*. Proceedings of The First North American Conference on Precision Dairy Management http://www.precisiondairy2010.com/conferenceproceedings.htm

Amos, H.E., Kiser, T., and Loewenstein, M. (1985) *Influence of Milking Frequency on Productive and Reproductive Efficiencies of Dairy Cows*. Journal of Dairy Science, 68:3, 732-739.

Workman, M. (2014) *New Media and the changing face of information technology use: The importance of task pursuit, social influence, and experience.* Computers in Human Behavior. 31, 111-117.

Rorie, R.W., Bilby, T.R., and Lester, T.D. (2002) *Application of Electronic estrus detection technologies to reproductive management of cattle.* Theriogenology 57. 137-148.

Saint-Dizier, M. And Chastant-Maillard, S. (2012) *Towards an Automated Detection of Oestrus in dairy Cattle.* Reproduction in Domestic Animals. (Online release prior to publication) http://onlinelibrary.wiley.com/doi/10.1111/j.1439-0531.2011.01971.x

DeLaval Australia http://www.delaval.com.au/

Lely Australia http://www.lely.com/en/milking

Insentec Australia http://www.daviesway.com.au/products/milking-systems/robotic-milkers.aspx

ANTI-MÜLLERIAN HORMONE: RELATIONSHIP WITH CALVING TO MATING AND CALVING TO CONCEPTION INTERVAL

S. J. Teirney[AB], K. R. Petrovski[A] and W. van Wettere[A]

[A]University of Adelaide, Adelaide, South Australia,
[B]Corresponding Author Email: sarah.teirney@adelaide.edu.au

Abstract

Fertility is a key issue in the Australian and global dairy Industries, causing significant financial loss. Anti-müllerian hormone (AMH) which is produced by the granulosa cells of ovarian follicles is positively correlated the Antral Follicle Count (AFC) of dairy cows. A high AFC is positively correlated with increased responsiveness to gonadotrophin stimulation, higher ovulation rate, and improved embryo quality and survival. The ovarian reserve may be impacted by conditions experienced in utero due to differences in maternal metabolic and health status as well as parity. The fertility of female cattle with a large number of healthy growing follicles may be less sensitive to the negative effects of poor metabolic status or sub-optimal environmental conditions, and these cows may have increased longevity and productivity. The aim of this study is to determine a correlation between AMH concentration and the length of time from calving to mating and calving to conception. Two groups (mature cows n= 30 and heifers n=30) will be studied. Blood samples to measure AMH concentration will be taken, as well as ultrasounds of the ovaries to determine AFC. Mating records will be collected to determine observed heats, number of inseminations to conception, time from calving to conception and maintenance of pregnancy. It is anticipated to show a significant correlation between AMH and calving to conception interval. Likewise, the number of inseminations per conception should be also reduced. This research will allow for development of a simple screening method to identify female cattle which will have a shorter calving to conception interval, thus improving production and reducing financial loss due to sub-optimal fertility. The same method could also be applicable for the selection of heifers.

Introduction

In recent decades, there has been a worldwide decrease in the fertility and reproductive efficiency of dairy cows, particularly in production systems which use cows selected for high milk production (Lucy 2001; Walsh *et al* 2011). Fertility is a multi-factorial trait and its deterioration is a combination of a variety of genetic, environmental and managerial factors and their complex interactions and additive effects, which make it difficult to determine the exact reason for this decline (Lucy 2001; Walsh *et al* 2011). Methods to improve the fertility of dairy cows include reducing the inter-calving interval and increasing the pregnancy rate (De Vries, 2006).

The ability to identify animals with a greater reproductive capacity would be highly advantagous. The number of primordial follicles present on the ovary, also known as the ovarian reserve, represents the maximum number of follicles available during a cow's lifetime, and is determined at birth (Ireland *et al*., 2008).

This number decreases during the reproductive life of the animal, but has been shown to be correlated with the number of growing follicles which leave this pool, known as the antral follicle count (AFC) (Erickson *et al* 1966). The AFC can be determined by ultrasonograhy.

However, to accurately phenotype cattle for fertility this procedure is too time-consuming for routine use. This is particularly important in trials due to the need for repeated measurements on individual animals and the invasive nature of the ultrasonography (Burns *et al*., 2005, Ireland *et al*., 2007). Therefore, an alternative method to determine AFC is needed.

Anti-müllerian hormone (AMH) levels in plasma are highly, positively correlated with AFC (r = 0.80 – 0.90) (Ireland *et al* 2008). Also known as Mullerian inhibiting substance (MIS), AMH is a homodimeric disulfide-linked glycoprotein hormone, belonging to the transforming growth factor-b (TGFb) superfamily of growth factors (Cate *et al*., 1986, Takahashi *et al*., 1986). The expression of AMH is restricted to the granulosa cells of small growing follicles (3 – 7mm), with a number of studies concluding that it is an accurate marker of the size of the pool of gonadotrophin-responsive follicles present in the ovaries of cows (Rico *et al*. 2009).

The mechanism of AMH is to be an intra-ovarian inhibitor of follicle activation. This function is achieved by inhibiting follicle recruitment through inhibiting the stimulatory effect of follicle stimulating hormone (Durlinger *et al.* 2001, Fortune *et al*., 2011). This suppression of both initial and cyclic recruitment prevents the premature exhaustion of the ovarian follicular reserve (Durlinger *et al.*, 2001, Grynnerup *et al*., 2012, Monget *et al*., 2012). The use of AMH has so far concentrated on selection of animals for embryo transfer programs, which typically involve the use of exogenous gonadotrophins to induce ovulation of a higher than normal number of oocytes (superovulation).The AMH concentration in plasma can predict the capacity of an individual cow to respond to gonadotrophin treatment (Rico *et al*., 2012).

This project has three primary aims. One, to determine whether there is a correlation between plasma AMH concentrations in early lactation and the calving to conception interval in Holstein-Friesian dairy cattle. Two, to establish, for the first time, whether AMH can be analysed in urine. Three, to determine whether plasma AMH levels post-partum are affected by the milk production and somatic cell count (SCC) of their dam during gestation.

Materials and methods

This study will be conducted at a commercial Dairy Farm located near Two Wells, South Australia. Sixty Holstein-Friesian cattle will be used (30 Cows and 30 Heifers). Samples will be collected from each animal at three time points; days 17 ± 4, 28 ± 4 and 42 ± 4 post-partum. Blood samples, urine samples and scanning by ultrasonography will be conducted at each of these time points. Heat detection dates, the number of inseminations and pregnancy rates will also be recorded.

Ultrasonography

Digital images will be taken using an ePoate ultrasound machine at 6 MHz. Each ovary will have images taken to obtain the AFC at a minimum of one time point. A record will also be made of the largest follicle and its size measured in mm.

Blood Sampling

Blood samples will be collected from the jugular vein into lithium heparin coated vacutainers

(Vacuette). Blood samples will be placed directly onto ice and transported to the lab within 1 - 2 hours of collection (Rico *et al*. 2009). Samples will then be centrifuged at 3,000 rpm for 15 min, to enable the collection of plasma, which will be pipetted into 1.5mL Eppendorf tubes and frozen until ready to be assayed.

Urine Collection

Urine will be collected from each animal. It will then be kept on ice until taken to the lab within 1 – 2 hours of collection. Samples will then be centrifuged at 1,500 rpm for 15 min to allow for the removal of solids. The urine is then pipetted into 1.5mL Eppendorf tubes and frozen until testing.

AMH ELISA

The testing of AMH in plasma will be conducted using the commercially available kit MIS/AMH ELISA Kit (Beckman Coulter, France). The plasma will be tested in the kit according to the manufacturer's instructions. The urine samples will be tested using the same method.

Milk Production Data

Cows and heifers from which AMH data is being collected will have their Dams identified. Milk production data, specifically their somatic cell count (SCC), will be ascertained, during the pregnancy period of the studied animal. This will then be used to identify if there is a correlation between the dam's SCC during pregnancy and their offspring's AMH. The data will be collected from previous Herd Test results obtained from the Testing company.

Conception Data

Conception data will be collected from the Dairy operation as it will occur in the day to day running of the farm. The information collected will include dates and times of any heats observed, dates and numbers of Artificial Inseminations, date of conception, which will be calculated using an Early Pregnancy Test at approximately 7 weeks post-insemination.

Data Analysis

Our data will be analysed using three separate statistical analysis programs; SAS, GenSTAT and SPSS with the results of these compared. The difference in the levels of AMH will be estimated using an analysis of variance (ANOVA), as well as the difference in the reproductive parameters. The effect of AMH (0 will be low AMH and 1 will be high AMH levels) will also be estimated using a linear regression against the reproductive parameters (e.g. days to first service, days to conception). A linear regression will also be used to compare urine AMH to plasma AMH concentrations.

Results

We expect to confirm the strong correlation between AFC and plasma AMH concentrations (Ireland *et al*. 2008, Rico *et al* 2009, Coyral-Castel *et al*., 2011).

We anticipate finding a strong correlation between AMH concentration in plasma and the interval from calving to conception. Such findings will indicate that a high AMH concentration relates to a shorter calving to conception interval. We also anticipate observing a reduction in the number of inseminations needed to achieve pregnancy in those animals with a higher AMH concentration.

Discussion

This study will assess the correlation between AMH concentration in plasma during early lactation with calving to conception interval and required numbers of inseminations per successful pregnancy in 30 mature cows and the equivalent number of heifers in the Holstein-Friesian breed of dairy cattle. The anticipated results are that there will be a strong correlation between the concentration of AMH in blood or urine and their reproductive capacity.

Such findings will allow for the prediction of the fertility of cows using an AMH measurement, which in turn will identify the animals AFC (Ireland *et al*. 2008, Rico *et al* 2009, Coyral-Castel *et al*., 2011). This will be important to determine as most studies have focused on the use of AMH in superovulation procedures, instead of in a commercial setting (Rico *et al*., 2012).

This study will be carried out using only cows and heifers of Holstein-Friesian breed. Previous reports have confirmed that breed does not affect the results. Therefore, findings of this study will be applicable to all dairy cattle. Further work will be required to detect if the same methodology can be used in selection for reproductive capacity in heifers before their first mating.

Results of this study can be used by dairy farmers in the determination of animals which will have an improved reproductive capacity compared to others. This will allow for the removal of those animals from the production system before continued breeding. This will reduce the economic losses incurred from retaining an animal with poor fertility. These losses include; lost income from milk sales due to fewer calves produced per year, an increase in semen costs because of an increase in the number of Artificial Inseminations (AIs) per conception, or additional costs due to culling of long time infertile animals (Coyral-Castel *et al*., 2011, Thatcher *et al*., 2006). This may also lead to the development of new breeding schemes to select for high fertility farm animals (Ireland *et al*., 2008).

In summary, the ability to detect and reduce fertility problems before they occur is of high importance to the dairy industry. The use of AMH in plasma has the possibility of being a convenient and relatively non-invasive method of determining the reproductive potential of individual female cattle.

Acknowledgements

The authors are grateful to the farm owners for their cooperation and use of animals, and The University of Adelaide for provision of space, facilities and financial support.

References

Burns, D.S., Jimenez-Krassel, F., Ireland, J.L.H., Knight, P.G. and Ireland, J.J. (2005). Biol. Reprod. 73, 54.

Cate, R.L., Mattaliano, R.J., Hession, C., Tizard, R., Farber, N.M., Cheung, A., Ninfa, E.G., Frey, A.Z., Gash, D.J., Chow, E.P., Fisher, R.A., Bertonis, J.M., Torres, G., Wallner, B.P., Ramachandran, K.L., Ragin, R.C., Manganaro, T.F., Maclaughlin, D.T. and Donahoe, P.K. (1986). Cell. 45, 685.

Coyral-Castel, S.,. Ramé, C , Monniaux, D., Fréret, S., Fabre-Nys, C., Fritz, S., Monget, P., Dupont, F. and Dupont, J. (2011). Theriogenology. 75, 1239.

De Vries, A. (2006). J. Dairy Sci. 89, 3876.

Durlinger, A.L.L., Gruijters, M.J.G., Kramer, P., Karels, B., Kumar, T.R., Matzuk, M.M., Rose, U.M., de Jong, F.H., Uilenbroek, J.T., Grootegoed, J.A. and Themmen, A.P. (2001). Endocrinology. 142, 4891.

Erickson, B.H. (1966). J. Ani. Sci. 25, 800.

Fortune, J.E., Yang, M.Y. and Muruvi, W. (2011). Reprod. Fert. Develop. 23, 15.

Ireland, J.L., Scheetz, D., Jimenez-Krassel, F., Themmen, A.P., Ward, F., Lonergan, P., Smith, G.W., Perez, G.I., Evans, A.C. and Ireland, J.J. (2008). Biol. Reprod. 79, 1219.

Ireland, J.J., Ward, F., Jimenez-Krassel, F., Ireland, J.L.H., Smith, G.W., Lonergan, P. and Evans, A.C.O. (2007). Hum. Reprod. 22, 1687.

Lucy, M.C. (2001a). J. Dairy Sci. 84, 1277.

Rico, C., Drouilhet, L., Salvetti, P., Dalbies-Tran, R., Jarrier, P., Touze, J.L., Pillet, E., Ponsart, C., Fabre, S. and Monniaux, D. (2012). Reprod. Fert. Develop. 24, 932.

Rico, C., Fabre, S., Medigue, C., di Clemente, N., Clement, F., Bontoux, M., Touze, J.L., Dupont, M., ,Briant, E., Remy, B., Beckers, J.F. and Monniaux. D. (2009). Biol. Reprod. 80, 50.

Rico, C., Medigue, C., Fabre, S., Jarrier, P., Bontoux, M., Clement, F. and Monniaux, D. (2011). Biol. Reprod. 84, 560.

Takahashi, M., Hayashi, M., Manganaro, T.F. and Donahoe, P.K. (1986). Biol. Reprod. 35, 447.

Thatcher, W.W., Bilby, T.R., Bartolome, J.A., Silvestre, F., Staples, C.R. and Santos, J.E. (2006). Theriogenology. 65, 30.

Walsh, S.W., Williams, E.J. and Evans A.C.. (2011). Anim. Reprod. Sci. 123, 127.

IMPACT OF AUTOMATIC MILKING SYSTEMS (AMS) ON LABOUR AND LIFESTYLE ON COMMERCIAL FARMS IN AUSTRALIA

J. Molfino[A] K. Kerrisk[A] and S.C. García[A]

[A]Dairy Science Group, Faculty of Veterinary Science, The University of Sydney, Camden (2570), NSW; Australia

Corresponding author. Email: juan.molfino@sydney.edu.au

Abstract

One of the key reasons farmers adopt Automatic Milking Systems (AMS) is related to the expected impacts on labour and the lifestyle benefits for the farmer. The aim of this research was to develop a pool of knowledge that will help researchers, farmers and industry representatives better understand the impact of AMS on labour and lifestyle on commercial farms in Australia. Labour and lifestyle audits were conducted on 5 commercial AMS farms to enable development of case studies that would act as a resource to help raise awareness and knowledge of AMS impacts on pasture-based farms within the Australian dairy industry. Audits were conducted on each of the 5 farms for three days every month over a 12 month period. Each farmer was surveyed to capture general information relating to labour and time management, labour implications during the transition to AMS, and the establishment of roles and routines after the transition period. This paper presents findings from the survey and the labour audit. Labour efficiency ranged between 100 and 273 cows/Full time equivalent (1 FTE = 50hs per week). All 5 AMS farmers stated that AMS had a positive impact on their quality of life and that their expectations around the impact of the technology were successfully fulfilled. These findings will contribute to existing industry knowledge and awareness, in order to increase the chance of farmers making more informed decisions regarding the adoption of robotic milking technology when they are considering the installation of new milk harvesting equipment

Introduction

Since the first commercial Automatic Milking System was installed in the Netherlands in 1992, there are now more than 10,000 (de Koning 2011) farms using this technology globally, with the vast majority of them being in housed systems operating within Europe.

In Australia, AMS was first commercially adopted in Victoria in 2001 but it was not until 2008 that a second commercial farm started operation. At present there are 23 farms operating in 6 different states (W.A., S.A., Vic, Tas, N.S.W. and QLD) within Australia including single boxes, double boxes and one robotic rotary. Another nine farmers are currently installing AMS on their farms and by the end of the year there is expected to be at least 32 robotic farms in operation.

There are currently 4 brands available on the Australian market (DeLaval, Insentec, Lely and GEA).

The recent uptake of AMS and the success of commercial installations, is stimulating increased interest in AMS within the Australian dairy industry. As labour is the most significant operational cost likely to be affected by AMS, it is not surprising that farmers contemplating AMS are seeking sound data regarding the impact of AMS on labour and lifestyle (less people are required to milk cows, less early morning starts, and reduced levels of physical work). Some of these benefits are also considered by the industry as important elements for improving the attractiveness of dairy work.

The aim of this research was to develop a pool of knowledge that will help researchers, farmers and industry representatives better understand the impact of AMS on labour and lifestyle on commercial farms in Australia.

Materials and methods

Labour audits were conducted for three days, every month, over a 12 month period and across 5 commercial farms.

The farms were selected to demonstrate the impacts of the technology with an array of farmer objectives around the adoption decisions. Each farmer/operator recorded time of day and duration of time for all tasks conducted during the auditing days in customised timesheets.

In addition, each farm was visited on at least three separate occasions to allow the researcher to observe the routines, validate the farmers labour records and develop an integral understanding of the operation.

Each farmer was surveyed prior to the commencement of the auditing to capture general information relating to labour and time management, labour implications during the transition to AMS, and the establishment of roles and routines after the transition period.

Results

Labour Before the commission of the AMS

Farmers were asked to provide information about the labour structure of their operation prior to the adoption of the AMS (Table 1).

Table 1. Labour efficiency operating with conventional milking system prior to AMS installation. Note: (FTE = full time equivalent, a standardized labour unit, calculated as 50 hours per week)

	A	*B*	*C*	*D*	*E*
Cows	400	-	170	320	370
FTE	4	-	1.64	4.28	3.5
Cows/FTE	100	-	104	75	106

Farmers A and C replaced an existing dairy with the AMS, farmer B was dry stock farming before the adoption, farmer D converted a run-off block and continues to operate the home farm plus the new conversion and farmer E commissioned the robots on a former dry stock area and sold the original property.

Reasons for adoption

Farmers were asked in a closed question to indicate the three main reasons why they decided to install AMS. The most common reason was ***labour flexibility***; followed by ***labour reduction*** and thirdly to improve ***milk quality and/or milk production***. Other responses included: ***personal health, profit, new challenge*** and ***keeping up with technological advancements***.

This was the individual results of the 5 surveyed farmers, but it is interesting to recognise that AMS might also be considered for the additional reasons:

- Existing dairy is outgrown or needs replacing – a new dairy is a significant investment and installation of a new conventional dairy indicates a commitment to physically milk cows for another 10-15 years.

- Dairy needs replacing and farmer considers retiring vs. milking cows for another 10-15 years. Adopting robots creates opportunity to prolong dairying career by easing the burden of physically milking cows.

- Ability to continue with existing operation whilst also converting an additional land area. This may allow the farmer to operate two properties without a significant increase in labour units.

- Ability to grow the business, particularly when land-locked as additional small farms may be available for lease/purchase and could host the robots while the farmer manages multiple properties.

- Robots might be a desirable solution to cope with reduced family labour if the next generation decide to leave the farm. Alternatively robots could also provide the incentive for the younger generation to come back into the business.

- Creates an opportunities for people to enter the dairy industry who have been averse to the routine or commitment to milking cows twice a day but who are attracted by the benefits of regular cash flow and other aspects of dairying.

Impact on labour

Hours worked

In order to try to identify the differences between conventional and automatic milking systems farmers were asked if they now work less hours than they did with conventional milking. We recognise that this is not the objective for all farmers so the response needed to be put into context for each operation. Only four of the five were dairying prior to the adoption of AMS and three of the four agreed that they now work less hours. One farmer chose to shift his time to different tasks and dramatically reduce the amount of employed labour in his operation. He has successfully achieved this objective.

Daily routines

With the conventional milking system and prior to the adoption of AMS (relevant to just four farmers), surveyed farmers spent on average 5.5 hours (range 4.5-7) every day milking cows. Milking no longer requires them to be present at set times at the dairy so we were interested to know how many of the farmers have actually changed their start-finish times/routines. All farmers agreed that their routines have changed considerably. The farmers tend to have shifted their start time (not leaving the house as early in the morning) but they have not shifted their finish times.

Shift in tasks

With the adoption of AMS there has been a change in the nature of their work in comparison to a conventional dairy. Some tasks are eliminated (milking sessions), some tasks are done in different ways or at altered frequencies (e.g. fetching cows, cleaning the dairy) and some new tasks have been introduced (computer monitoring, robot maintenance). Not having to schedule and plan the whole day around the milking sessions was reported by farmers as one of the biggest changes.

Shift in focus

Three out of 4 farmers (75%) believe that they now have more time to focus on the management aspects of their operation. Before the commissioning of the AMS, surveyed farmers spent on average 60% of their working day harvesting milk. The robots have freed farmers up from defined milking sessions and has given them the opportunity to spend more time on the management aspects where they can have a greater impact on productivity (e.g. pasture management, nutrition, animal health, reproductive performance). They also report that they now have more confidence when taking management decisions, because the system provides them with a whole new level of information in regards to things like milking frequency, concentrate intake, and deviations in milk yield (per quarter). Management generally involves planning, record keeping and data interrogation and to do this does require some time.

Monitoring system

Seventy-five percent of the surveyed farmers reported that they spend more time in the office compared to what they did with their conventional system. More time in the office usually means more time on the computer and this is because an automatic milking system generates a large amount of daily data that allows the famers to manage the herd and the system.

Some of the daily actions that the farmer needs to do on the computer are to check summary reports, set auto-drafting for cows that need attention, check alerts, review daily performances, and entering new records to ensure that data is always up to date.

The AMS gives the farmer the option to monitor and manage the system remotely (whilst off farm). This allows them to see where cows are trafficking to, check cow traffic and milkings that have occurred overnight, see how many cows have been drafted to the treatment pen/paddock and the list goes on. Some brands of AMS allow the operator to interact with the equipment remotely whilst others only allow for remote monitoring of data/system.

Less physical work

The majority of the (75 %) surveyed farmers agree that they are now doing less physical work on a daily basis. Not having to fetch the whole herd to the dairy and not having to stand on a concrete floor for several hours manually attaching cups are the two main physical activities that can be removed with AMS.

This also brings potential occupational health and safety benefits for farmers and their staff. On average the surveyed farmers spent 5.5 hours per day total in both milking sessions when operating with a conventional system. The one farmer who responded that the amount of physical work has not decreased is continuing to operate the conventional dairy and the robotic dairy.

Employed labour

Four farmers reported that they have reduced the total cost of employed labour in comparison to the system prior to the adoption of AMS, by reducing the number of employed labour, by reducing the number of hours worked or a combination of the two. Farmers also reported savings in regards to not having to hire external contractors because they now have more time and flexibility to do jobs like sowing, forage conservation, , fencing.

Again the one farmer that didn’t report a drop in the cost of employed labour is the farmer that is operating the two systems – the labour cost per litre of milk would have dropped significantly since he is now milking significantly more cows without increasing his labour pool.

Labour efficiency

Results from the labour audit are presented in Table 2.

Table 2. Labour efficiency operating with AMS (Full time equivalent is a standardized people unit, calculated as 50 hours per week)

	A	*B*	*C*	*D*	*E*
Cows	**152**	**140**	**210**	**205**	**275**
FTE	**1.52**	**0.75**	**1.33**	**0.75**	**1.44**
Cows/FTE	**100**	**186**	**157**	**273**	**191**

Labour efficiency ranged between 100 and 273 cows/FTE which is considered at a large range. Through additional information we understand that the labour efficiency is predominantly affected by the objectives that the farmer had with the installation of the robots and how they are integrated with the farming operation.

We cannot compare the labour efficiency of their operations before and after AMS adoption as the before data is not based on labour audits. Also, and more importantly only two of the audited farms have shifted from conventional to robotic milking on the same farm and without significantly modifying the herd size. Interestingly all but one of the farms have a labour efficiency that would be considered to be significantly higher than the industry average which hovers around 100 cows/FTE. Farmer A didn't improve the labour efficiency when adopting robots but his main objective was to decrease the amount of employees and eliminate the need to physically milk cows. Reducing the amount of physical work has allowed him to remain in the industry when his only alternative was to exit the industry due to health issues. His is an interesting case as he operates the system with batch milking rather than voluntary milking so he tends to spend his time fetching herds to the dairy rather than physically milking cows.

Table 3 shows a comparison of Labour Efficiency data from different Australian regions and the average of the 5 cases studies.

Table 3. Labour efficiency. Data sourced from: Tasmania Benchmarking 2013, Dairy Farm Monitor Project – Victoria Annual report 2012/2013 and Dairy Farm Monitor Project – New South Wales Annual Report 2012/2013

	Case Studies Average	**N.S.W**	**VIC**	**TAS**
Cow /FTE	**181**	**76**	**99**	**137**
Average Herd size	**196**	**350**	**323**	**514**

Average Labour efficiency (Cow /FTE) for the case studies is higher than the figures shown for Victoria, New South Wales and Tasmania, even when the herd is smaller. It is recognised that labour efficiency tends to improve as the scale of the operation increases.

Labour flexibility

All 5 farmers (100%) agreed with the statements that **"most of my daily tasks can be conducted up to 2 hours earlier or later on occasions if needed"** and **"it is not a problem if I decide to sleep in and go to the farm a couple of hours later on occasions".** This is a reflection and on the flexibility that the AMS provides to farmers and it is considered by them as one of the main advantages. Although all of them follow daily routines many of the tasks are not required to be conducted at fixed times. The farmer no longer needs to schedule their day around the milking sessions. Even the one farmer that batch milks multiple herds reports a certain level of flexibility in the daily operation.

Farmers were asked if they have any off farm employment, and 3 out of the 5 (60%) responded that they have a second job not related with dairy farming and that the flexibility the AMS provides them is key to allow them to do this. One of the other 2 farmers still runs a second dairy farm with a conventional system, and the flexibility in terms of labour and the possibility of managing many aspects of the AMS farm remotely allows him to manage both farms.

Implications on Quality of life

All 5 AMS farmers declared a positive impact in their quality of life and they also responded that the expectations they had of the technology were successfully fulfilled.

Conclusions

This paper reports on the results of a survey of 5 AMS farmers and the labour audits conducted on each farm. All 5 farmers reported a positive impact of the adoption of the automatic systems on labour. These findings will contribute to industry awareness and knowledge to increase the chance of farmers making informed decisions regarding the adoption of robotic milking technology when they are considering the installation of new milk harvesting equipment.

Acknowledgments

We acknowledge the support of the Dairy Research Foundation. This work was conducted through the FutureDairy program which is funded by Dairy Australia, NSW Department of Primary Industries, DeLaval and The University of Sydney.

References

De Koning K (2011). Dairy Research Foundation: Current Topics in Dairy production Proceedings 16:14