Review and recommendations on mastitis issues in the Victorian dairy industry

A review for the Gardiner Foundation

by

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Contents

Summary and recommendations

The core of the current Australian 'knowledge-base' for mastitis resides in five sets of materials: the Countdown **Farm Guidelines for Mastitis Control** (updated in 2010) and the accompanying **Technotes**; a chapter on **Milk Quality and Milk Harvesting** in the report for Dairy Moving Forward (2010), and parts of a chapter on **Automation and Information Technologies** in the same report; and the **Proceedings of the 'International All Stars' Mastitis Control Symposium** (March 2010).

The dominant mastitis-causing organisms in Australian herds used to be the contagious pathogens *Staph aureus* and *Strep agalactiae*. During the last 10–20 years, however, *Strep uberis* has become the dominant mastitis pathogen and other environmental pathogens such as *E. coli* also appear to have increased in prevalence. The prevalence of *Staph aureus* and *Strep agalactiae* have declined but these pathogens still cause problems in many herds. Although *Mycoplasma bovis* has appeared as a problem in some herds, the jury is still out on the prevalence and economic significance of this pathogen in Australia.

Based on a review of 21 recent and current mastitis-related research projects in Australia, and an assessment of gaps in our current knowledge about mastitis, my short-list of priorities for further mastitis research is:

1. ***Strep. uberis* -** further research is needed to answer or to clarify aspects of prevention or management of this predominant cause of mastitis on Australian dairy farms. As of this date, Countdown's working group on *S. uberis* has an initial list of 8 potential gaps in knowledge about how best to prevent or to deal with this pathogen. The working group is expected to develop a clearer summary of gaps and priorities by mid-February.

2. ***Mycoplasma* -** instead of (or in addition to) determining the prevalence of Mycoplasma mastitis in Victorian herds, the PCR test should be used to examine a selection of clinical samples submitted to one or more Victorian microbiology laboratories, the aim being to determine what proportion of 'no-growth' clinical cases might be caused by *M. bovis.* Furthermore, the sensitivity and specificity of the PathoProof PCR assay for *M. bovis* could be evaluated, if desired, by using the collection of samples from clinical cases of Mycoplasma mastitis at the U of Sydney.

3. ***Str agalactiae* -** it is possible that SCC and incidence of clinical mastitis will be increased by incomplete milking of cows infected with this pathogen. A further short study is needed to clarify this issue for advisers and, perhaps, allow more farmers to take advantage of the remarkable results of recent research on Shorter Milking Times.

This review of recent and current projects indicates a surprising amount of mastitis research activity in Australia, resulting in some useful progress during the last decade. Notable examples include the social research projects conducted under the Countdown banner, the Shorter Milking Times research outcomes, and the marked reduction in new infection rates associated with the use of Teatseal at drying-off. However, the review also reveals a depressingly piecemeal approach to mastitis research during this period. The disparate collection of relatively small, 'opportunistic' projects reflects the lack of a coherent national strategy for mastitis research combined with a chronic shortage of research funds and research personnel.

Two developments in automation technologies – rapid automated tests for mastitis pathogens, and in-line sensors for monitoring udder health during milking – have the potential to substantially improve mastitis management on Australian dairy farms.

1. A comprehensive set of rapid automated tests for mastitis pathogens, known as the PathoProof system will be launched officially in March 2011 in conjunction with Dairy Technical Services. It is possible that some specialised training for regional veterinarians, some independent oversight and/or targeted funding might facilitate the introduction of this new technology and, thereby, help the development of a substantially faster, more reliable and cheaper pathogen identification service for the Australian dairy industry.

2. Use of automatic in-line sensing systems for monitoring mastitis in dairy cows is expanding. However, early adopters have had mixed results due to lack of knowledge and training, technical teething issues and management adaptation. Currently there is a lack of industry investment in this area. Farmers need independent advice and guidance but the number of advisers with milk harvesting expertise, especially in states other than Victoria, is very limited. There is an urgent need for training at both technical and post-graduate levels to ensure that competent advisers are available to help farmers negotiate the coming automation/information revolution.

The provision of one or more scholarships for selected post-graduate projects would be a very effective way to encourage the rebuilding of research skills and, at the same time, would add to the national knowledge-base on mastitis.

From 1998 to about 2007, the D and E activities of the previous Countdown project were guided by an industry group with wide-ranging representation, known as the Australian Mastitis Advisory Council (AMAC). A similar industry Council should be established again now to support and guide the new Countdown project - which was revived and re-constituted in 2010 but with limited funding from Dairy Australia. A revised AMAC, working together with the new Countdown team, would offer the best potential to act as the national 'centre' for overseeing the development of a coherent, national infrastructure for mastitis R, D and E, and for co-ordinating and rebuilding the skills needed to help Australian farmers manage mastitis in their herds.

To encourage industry/stakeholder engagement, the Gardiner Foundation should consider funding a short (half-day?) workshop involving farmer representatives, milk processors, plus selected researchers, veterinarians and advisers with a particular interest in mastitis and milk quality. The purpose would be to outline the scope and results of this review, to seek critical comments on its recommendations, to discuss the re-establishment of the Australian Mastitis Advisory Council (AMAC), and to encourage industry stakeholders to accept 'ownership' for the agreed priorities and activities for further R, D & E on mastitis issues in the Australian dairy industry.

The quickest and most effective way to re-establish the AMAC would be to invite at least 2 farmers with vision and drive to join with selected members of the DMF Expert Group who participated in the recent DA-funded industry survey of mastitis and milk quality problems and who then delivered the Milk Quality and Milk Harvesting chapter for Dairy Moving Forward, Strategy 3 in October 2010 (see footnote, page 31, for a full list of members).

1. Main science-based issues around mastitis in Australia

1a. Scientific knowledge-bases for mastitis in Australia

Australia's first national 'knowledge-base' was the report of the Expert Panel on Bovine Mastitis in 1966. Following submissions to the Standing Committee on Agriculture by the Australian Veterinary Association and the Australian Society of Dairy Technology in 1965, the Animal Production Committee established an Expert Panel on Bovine Mastitis[2]. Their report led to the development and widespread promotion of a mastitis control program that became known as the 'Five Point Plan'. The original five points were:

1. Correct adjustment and proper use of milking machines.
2. Removal of the source of infection (by detecting infected cows with the California Mastitis Test [CMT] and bacteriological examination of CMT positive quarters) followed by application of suitable treatment, segregation and culling.
3. The use of clean, cold, running water for back-flushing of teatcups and washing of udders to prevent the spread of infection from cow to cow.
4. Post-milking sanitization of teats with a suitable preparation.
5. Efficient treatment.

This strategy of control was widely adopted and, when implemented correctly, quite successful for controlling contagious mastitis. Its aim was to reduce the prevalence of infection by reducing both the new infection rate and the average duration of infections. It was assumed that *Str. agalactiae* could be eliminated with this strategy but that eradication of *Staph. aureus* or *Str. dysgalactiae* would be more difficult because these pathogens can persist in secondary sites.

Over the following 30 years, the Five Point Plan gradually became less focussed and less successful for three main reasons.

> First was the difficulty of implementing some of these steps on typical Australian farms. (What, exactly, did Point 1 mean, for example? How could infected cows be segregated easily and reliably to achieve Point 2 in pasture-based dairy herds? How could Australian farmers balance the labour requirements of milking to achieve Point 3 and was it cost-effective?).
>
> Secondly, the 'Five Point Plan' gradually morphed into several different versions of the 'Five Points' and also into a modified plan known as a '3 x 3 x 3' Control Plan.
>
> Thirdly, and most importantly, the various Five Point Plans were not particularly successful in dealing with the progressive increase in prevalence of mastitis caused by environmental pathogens, such as *Str. uberis, E. coli* and *Pseudomonas spp*., which are so widespread in the cows' environment.

[2] 1966 Expert Panel on Bovine Mastitis: Prof D.C. Blood (Convener), D. Flynn, G. Loftus Hills, G. Mein, D. Murnane, J. Feagan

The next truly national, scientifically-based knowledge-base was the **Farm Guidelines for Mastitis Control**, first published in 1998 by the then Dairy Research and Development Corporation and distributed to every dairy farmer in Australia at that time. The Farm Guidelines were developed by the Australian Mastitis Advisory Council's Countdown Downunder technical group[3] with critical input from dozens of professional service providers, farmer leaders and other interested individuals.

The Countdown Downunder plan provided a set of guidelines for each of six key periods of a cow's milking year (Calving, Lactation, Late Lactation, Drying Off, Dry Period, and a Review Period). The aim of the Guidelines was to explain to farmers: what has to be done; why it should be done; how to do it; and, importantly, how to check that it has been achieved.

The Farm Guidelines were underpinned by a series of Technotes which outlined the research and observational data that provided the rationale for each of the individual guidelines. The Technotes, together with a series of FAQ sheets, were developed especially for dairy service providers (eg, veterinarians, factory field officers, milking machine technicians). The main aims of the Technotes were: to promote clear, consistent messages about mastitis control for use by all udder health advisers and milk quality advisers throughout Australia; to indicate the degree of confidence in each of the recommendations given in the Farm Guidelines; and to provide references to key research papers for further reading.

An excellent 10-year summary of the background, development, activities, successes and problems with implementation (eg, due to drought, low milk prices, high feed costs) of the Countdown Downunder national program is given in Brightling et al. 2010[4].

The core of the current national knowledge-base for mastitis comprises five sets of materials.

i) An updated version of the 1998 Countdown **Farm Guidelines for Mastitis Control**. Early in 2010, Dairy Australia provided limited funds for updating and converting the Farm Guidelines into electronic format, and also for a scoping study of new or revived activities under a Countdown banner[5] for the Australian dairy industry. The updated Farm Guidelines were posted on the DA website in September 2010 (http://www.dairyaustralia.com.au/Farm/Mastitis-and-milk-quality.aspx).

ii) The Countdown **Technotes**, some of which have been updated recently, are now available in electronic format on the DA website via links at the end of each individual Farm Guideline. One additional Technote is in the pipeline. The purpose of this new Technote is to help Australian dairy farmers prevent new infections caused by *Strep uberis,* and to treat existing *Strep uberis* infections, more effectively.

iii) The chapter on **Milk Quality & Milk Harvesting** in a report for Dairy Moving Forward, Animal Performance R D & E, Strategy 3 (October 2010). Part of this chapter is relevant to science-related mastitis issues as discussed later (Section 1d).

[3] 1998 Countdown Downunder technical group: P. Brightling (Project Leader), J. Malmo, G. Mein, D. Ryan

[4] Brightling, PB, RD Dyson, AF Hope and J Penry. 2010. A national program for mastitis control in Australia: Countdown Downunder. International All Stars Mastitis Control Symposium, Melbourne, March 2010.

[5] 2010 Countdown team: J. Penry (Project Leader), P. Brightling, A. Hope, J. Malmo, G. Mein, H. Pitman

iv) Part of the chapter on **Automation and Information Technologies** in the same report for Dairy Moving Forward, Animal Performance R D & E, Strategy 4 (Investigate novel approaches to improve farm productivity).

v) **Proceedings of the 'International All Stars' Mastitis Control Symposium** held in Melbourne, March 2010, under the joint sponsorship of Boehringer Ingelheim, Dairy Australia and the University of Melbourne. Seven mastitis experts from 6 countries presented their perspectives on what's new and how this new information could be applied in Australian dairy herds.

A potential '6th leg' for our Australian knowledge base is under development in New Zealand at present. In 2009, the NZ dairy industry funded the establishment of a new team of mastitis experts - roughly equivalent to Australia's re-constituted Countdown project team. Their tasks include reviewing and 'Kiwi-ising' Countdown's series of Farm Guidelines and Technotes, and reinvigorating specialist training in mastitis management for NZ advisers and farmers. The new NZ program is known as 'SmartSAMM'. Given the similarity of dairying conditions in Australia and NZ, the new NZ program is likely to produce new materials and information that can be applied successfully by Australian advisers on Australian dairy farms.

The Countdown Farm Guidelines and series of Technotes also form the blueprint for development of a new national program for managing mastitis in Ireland, with critical input from P. Brightling and J. Penry.

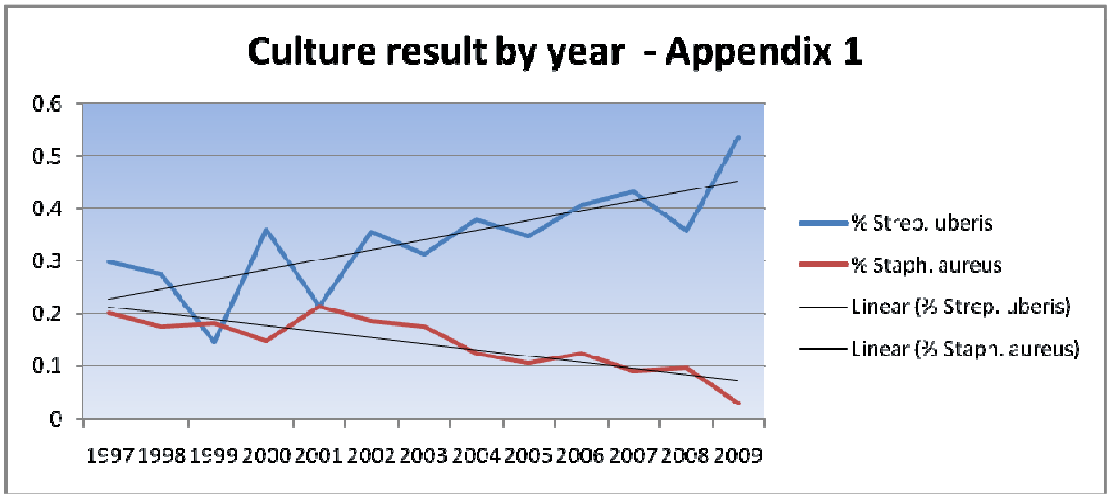
For the record, the initial emphasis of the Countdown program in Australia was to encourage the development of pro-active regional adviser networks and to improve the competence of regional adviser teams in trouble-shooting on farms with particular mastitis problems. The main emphasis has now evolved into monitoring and managing mastitis risks on most farms.

1b. Trends for mastitis pathogens in Australian dairy herds

In the 1960s and up to about the early 1990s, the dominant mastitis-causing organisms in Australian herds were the contagious pathogens *Staph aureus* and *Strep agalactiae*. Other, less common pathogens during this period included *Strep dysgalactiae* and *Strep uberis*. A remarkable change has occurred during the last 10 – 20 years, however. *Strep uberis* has now become the dominant mastitis pathogen throughout Australia. Other environmental pathogens (including *Pseudomonas spp, B. cereus, E. coli*) and, perhaps, *Mycoplasma bovis* appear to have increased in prevalence during this period too.

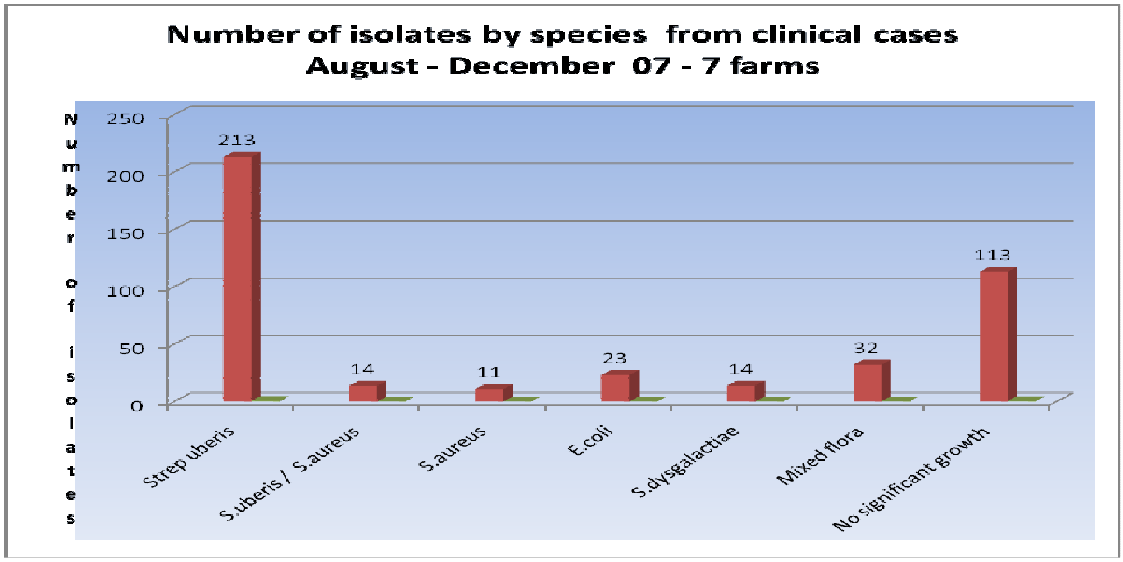
As an illustration of the change in emphasis in mastitis control since the Expert Panel report was published in 1966, it is noteworthy that Countdown Downunder's first Farm Guideline (and its supporting Technote 1) is all about reducing exposure to environmental mastitis bacteria.

The need for this major change in our national approach to mastitis control is clearly illustrated in the following two graphs supplied by Dr Jakob Malmo. The first graph is based on the results of milk samples submitted to the laboratory for culture (submitted because of either high cell count, or clinical mastitis) over a 13-year period to 2009 from herds in the Macalister Irrigation District. These data demonstrate the remarkable increase in *Strep uberis* infections over this 13-year period and the gradual decline in the proportion number of samples from which *Staph aureus* was cultured.



The second graph, based on a snapshot of clinical data in Aug-Dec 2007, also illustrates the importance of *Strep uberis* as the predominant cause of clinical mastitis in dairy herds in the Macalister Irrigation District.

A new, more extensive, unpublished analysis of clinical records for the MID by Dr Malmo, covering a 4-year period from 2006 to 2009, shows that *Strep uberis* accounted for 38%, *Staph. aureus* for 12%, *E. coli* for 5%, *Strep dysgalactiae* for 2% and *Strep agalactiae* for 1% of the total of 2122 clinical cases. The average proportion of 'No significant growths' was 26%.



These data-sets for the MID raise at least three interesting questions:

1) **Could the high number of 'no-growths' (26%) include unidentified *Mycoplasma bovis* and some more *E. coli* mastitis cases?**

Why? Because one of the challenges with identification of *Mycoplasma sp*. is that it does not show up on a routine culturing program for mastitis bacteria. As for *E. coli* clinical cases, a typical characteristic is that, by the time clinical symptoms occur, the cow's immune system has already knocked out this pathogen - leaving only its bacterial endotoxin as the enduring cause of clinical symptoms.

2) **Do these Macallister data reflect similar trends in other Australian dairying regions?**

Anecdotal reports from veterinary practitioners in other regions of Victoria or Australia indicate that:

- *Strep uberis* has become the dominant mastitis pathogen in most other dairying districts.
- The proportion of 'no-growths' found in the MID reflects a similar pattern in other regions.
- The incidence of clinical cases due to *S. aureus* may be higher in other regions compared with the relatively low incidence in the MID. Clinical cases due to *S. agalactiae* (only 1% in the MID data) may be more common in some other regions. An unpublished study by P. Mansell & G. Browning (U of Melb) showed a herd prevalence of about 7% of Australian herds in 2008, the highest proportion of *S. agalactiae* positive herds being in New South Wales and Queensland. In another unpublished study, DTS used the PathoProof PCR test on 277 bulk milk samples from northern Victoria. Of these, 32 gave a ++ reaction and 21 gave a + reaction to *S. agalactiae*. According to Dr R Dyson, this proportion (~19%) is in keeping with his findings in northern Victoria.

- Clinical cases due to *E. coli* are likely to be similarly low in other pasture-based dairy regions but higher for non pasture-based dairy herds.

A recent report on the prevalence of mastitis pathogens in high-producing intensive dairy herds in New South Wales was published by Shum et al. (2009)[6]. Environmental pathogens made up 91% (555/610) of isolates. These included coliforms (33.6%, of which *E. coli* was by far the most common), environmental Streptococcus (41.6%, of which *Strep uberis* was the most common, followed by *Strep dysgalactiae*). Contagious pathogens were uncommon, comprising only 2.5% (15/610) of the total isolates.

As for our nearest international dairying neighbour, the distribution of pathogens in clinical samples from 38 spring-calving herds in the Waikato region of NZ (S. McDougall, 1999[7]) was broadly similar to the MID data No bacteria were cultured from 28% of clinical quarters. Of the quarters from which bacteria were cultured, 75% were *Streptococcus uberis*, 10% were coagulase negative staphylococci, 5% were Coliforms, 4% were *Streptococcus dysgalactiae*, only 3% were *Staphylococcus aureus* and 3% were other species of bacteria. Clinical mastitis was diagnosed in an average of 10% of calved cows within the herds. Penicillin resistance was detected in 25% of 44 *Staphylococcus aureus* isolates, 0% of 10 *Streptococcus uberis* isolates and 100% of 12 *E. coli* isolates.

3) Why has *Strep uberis* become the dominant mastitis pathogen in most Australian (and NZ) herds?

Given the intensification that has occurred in the dairy industry over the last 20 years, the increased incidence of *Strep. uberis* mastitis is likely to be associated with increased exposure to the pathogen. *Strep. uberis* is widespread in manure (especially in the fresh green variety where cows are concentrated on pasture). Zadocks[8] thinks of *Strep. uberis* primarily as a problem for pastured herds and notes, for example, that the *Strep. uberis* new infection rate is higher in the pasture season in The Netherlands compared with the housing season. Changes in typical farm systems (including widespread use of calving pads and feed pads, higher densities of cattle especially around water troughs, gateways and laneways, and higher producing cows) appear to have increased the environmental risks of infection.

The vast majority of Australian and NZ farmers do not wash or clean teats before milking and, often, teats are coated with fresh green manure when teatcups are applied. Given that many teats are routinely bathed in a broth of milk that must be highly contaminated with *Strep. uberis* (at least at the beginning of milking), it seems probable that this could be contributing to at least some of our high case-rates of *Strep. uberis* mastitis.

There is a further possible explanation – that is, the possible development of *Strep. uberis* strains which are becoming more cow-adapted and possibly harder to treat.

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[6] LWC Shum, CS McConnel, AA Gunn and JK Housea. 2009. AVJ 87:12, 469

[7] McDougall S. 1998. Proceedings of the New Zealand Society of Animal Production, Volume 58, pp 76-78

[8] Zadocks, RN. *Streptococcus uberis* – What is new and what is for you? International All Stars Mastitis Control Symposium, Melbourne, March 2010.

1c. Current management practices for mastitis

Recommended current practices are described both in broad terms and in careful detail in the Farm Guidelines for Mastitis Control. The rationale for each guideline is given in the accompanying Technotes.

The main industry-agreed goal of this national program is to achieve a bulk milk cell count (BMCC) under 400,000 cells/ml for all of the vats of milk collected from all Australian farms and, furthermore, 90% of vats with a BMCC less than 250,000 cells/ml. A subsidiary goal has been to build the competence and capacity of service providers, thereby increasing their ability to respond to issues and to support farmers in all dairying regions. Neither of these goals has been achieved fully at this stage. In fact, the overall level of competence and capacity of one key industry sector (milking machine technicians) has gone backwards during the past decade. Although this is a core problem for the dairy industry, it is essentially a workforce and training issue rather than a science issue, of course.

A third goal of the national program has been to give individual farmers the knowledge and management skills to enable them to stay in premium quality class (if that is their goal) or to avoid any down-grade classification (involving a financial penalty) if that is their main need. There is no doubt that mastitis management has become more complicated for farmers over the past 50 years - for a variety of reasons. These include greater demands for higher quality of milk at the farm gate, changes in the patterns of infection and types of main pathogens, greater reliance on non-family labour for milking larger herds, the added complications of split-herd calving or year-round calving on mastitis control strategies, and last but not least, the problem of keeping up with the shifting goal posts, as outlined briefly below.

Keeping up with the shifting goal posts

Up until about 50 years ago, milk that looked visibly normal could be delivered to the bulk tank for sale. In the 1960s, the primary goal of mastitis management was simple:

- ***to reduce or eliminate the clinical symptoms of mastitis***.

By the 1970s, largely because of extensive research studies in the UK, the primary goal of mastitis management had become:

- ***to reduce the levels of infection in the herd.***

By the early 1990s, an additional goal started to become increasingly important to producers in many parts of the world, viz:

- ***to manage the bulk milk cell count,***

This new goal evolved because the European Union decided that milk with a BSCC <400,000 cells/mL was not fit for human consumption (EEC Directive 92/46/EEC8). Financial penalties imposed on producers for milk supplies with high BSCC or premium payments for low BSCC began to have a significant effect on farm profitability. Consequently, the recommendation to treat udder quarters that may be sub-clinically infected in early lactation became more common, the aim being:

- ***to improve udder health and the compositional quality of milk.***

In the late 1990s, a recommendation to add yet another goal was published. According to UK researchers, cows with mastitis have greater sensitivity to pain even when the mastitis is only mild or moderately severe. The new goal was:

- ***to recognise and control pain and inflammation caused by mastitis***.

Super-imposed on all of these goals, the goal of keeping antibiotics out of the milk supply has become an increasingly stringent requirement ever since penicillin was first used for treating clinical mastitis (in the 1950s). Because new test methods can detect extraordinarily low concentrations of inhibitory substances in milk, farmers can no longer rely on a "solution by dilution" approach to the use of antibiotics.

1d. Recent and current mastitis-related research projects in Australia

The following table is an extract from the Dairy Moving Forward, Animal Performance report (Strategy 3, Milk Quality & Milk Harvesting, October 2010). It lists some of the recent and current projects on milk quality and milk harvesting in Australia. Of these, nine (those listed in bold in the table)* could be classed as mastitis-related research projects and are described or discussed briefly below.

Existing and recent key investments

Project or activity name	Organisation responsible	Completed or ongoing
Countdown Downunder	Dairy Australia	1998-ongoing
CowTime	Dairy Australia	2001-2009
Genes associated with the virulence of *Strep uberis*	RMIT (Margaret Deighton)	Ongoing
Cow-side diagnostic testing for mastitis pathogens	University of Melbourne*	?
Incidence of *Strep uberis* in the Macalister Irrigation District	Maffra Veterinary Services (Jakob Malmo)	Completed
Differentiating between existing and new infections of Strep uberis	RMIT (Margaret Deighton, Jakob Malmo)	Ongoing
Field evaluation of PathoProof Mastitis PCR Assay	Dairy Technical Services	Ongoing
Benefit Cost Analysis of using teat sealants	Warrnambool Veterinary Clinic	Ongoing
Heifer mastitis incidence and factors involved	Dairy Australia (Lauren Clyne veterinary intern)	Ongoing
E-learning QA training for farmers	NCDEA	Ongoing
Effective cow mastitis vaccination: growth curve tests	RMIT (Margaret Deighton)	June 1998-ongoing
Incidence of *Mycoplasma bovis* in eastern Australia dairy herds and development of molecular diagnostic tests	Geoffrey Gardiner Dairy Foundation (University of Sydney, John House)	Ongoing
APVMA guideline for when new chemicals are registered	Dairy Australia (Technical Issues Group)	Ongoing
Use of Bovine Viral Diarrhoea testing in high BMCC herds	University of Adelaide (Michael Reichel), Bega RLPB	Ongoing
Better understanding of liner compression to control its effects on teat end condition	Doug Reinemann (University of Wisconsin) and Graeme Mein	Ongoing
Research into various aspects of Automatic Milking Systems	Future Dairy (Dairy Science Group)	Ongoing
Green Cleaning Project	Victorian Government's Sustainability Fund, Geoffrey Gardiner Dairy Foundation (AgVet)	Aug 2008-ongoing
Milking plant hygiene training pilot	NCDEA, WCBF (Gabby Hakim)	Ongoing
Milk cooling	Dairy Australia (TI Group)	Ongoing

*The project highlighted in yellow remains a mystery. None of the organisers or scribes for the relevant DMF meeting has any recollection of who added this project to the group list or who was doing the work. Dr P Mansell (U of Melb) has no knowledge of anyone at the U of M with a project on cow-side diagnostic testing.

1d (i) Projects of particular interest to the Gardiner Dairy Foundation

Field evaluation of the PathoProof Mastitis PCR Assay (Dairy Technical Services)

I agree with the Gardiner assessment panel's decision not to fund this project proposal. Firstly, the project description is essentially an evaluation of an existing commercial product rather than an original mastitis research study. Secondly, although the concept of automated screening of bulk tank milk samples for a range of mastitis pathogens is appealing, there will be real problems with interpretation of the data. Of the twelve organisms listed, only two (*Strep agalactiae* and *Mycoplasma bovis*) could be claimed to have originated unequivocally from within a cow's udder. Although any of the other ten organisms may have come from within an udder, it is equally likely that they may have originated from the teat skin or external teat orifice, from dirty or cracked rubberware, or from manure, airborne dust or a contaminated water supply.

In defence of the DTS proposal, however, note that Dr J. Malmo and Dr P. Mansell are mentioned as being involved in the proposed project. Both are experienced veterinarians who will be keenly aware of the limitations of bulk tank screening for pathogens and of the need for careful interpretation and systematic follow-up testing of individual animals which may be considered as 'high-risk' cows.

Incidence of *Mycoplasma bovis* in eastern Australian dairy herds and development of molecular diagnostic tests. Gardiner Foundation (University of Sydney, John House)

INN-09-017

The original project proposal was clearly presented. Its authors made a convincing case for the work despite the fact that, at this stage, the jury is still out regarding the prevalence and economic importance of Mycoplasma mastitis in Australia. According to the milestone report dated Aug 2010, the PCR test is working reasonably well now - of 109 samples from clinical cases of Mycoplasma mastitis collected by the University of Sydney, 83 were confirmed as *Mycoplasma bovis* and 7 as *Mycoplasma californicum.*

Two possible modifications to this project should be considered:

1. Instead of (or in addition to) determining the prevalence of Mycoplasma mastitis in Victorian herds, the PCR test should be used to examine a selection of clinical samples submitted to one or more Victorian microbiology laboratories, the aim being to determine what proportion of 'no-growth' clinical cases might be caused by *M. bovis.*

2. The sensitivity and specificity of the PathoProof PCR assay for *M. bovis* could be evaluated, if desired, by using the collection of samples from clinical cases of Mycoplasma mastitis at the University of Sydney.

Incidentally, and with the benefit of hindsight, perhaps one might question the choice of the word 'simple' to describe the goal of developing a simple, rapid and cost-effective LAMP method for detection of Mycoplasma. The fact that the project is now running behind schedule because of technical difficulties with the development of the LAMP test suggests that it might not be quite so simple.

INN-10-008 Strategies for low-cost molecular screening of contagious pathogens. The objectives of this project are:

- To develop cost-effective sampling protocols for detecting Mycoplasma infected cows within Mycoplasma infected herds using the LAMP diagnostic platform
- To develop a LAMP assay for detection of *Strep agalactiae* to provide a rapid cost-effective diagnostic system compatible with automation and application in herd testing laboratories.

While the statement may be true that the LAMP method offers the potential of a significantly lower cost per test compared with a PCR test for Mycoplasma, or for *Strep agalactiae*, the economic justification for this statement is not made clear in the project proposal.

In the absence of this economic justification, it is not clear (to me, at least) why Gardiner should be funding a project which includes:

- the development of a PCR test for *Strep agalactiae,* given that two such tests are available in Victoria already (PathoProof, DTS; P. Mansell, Uni of Melbourne).
- the development of a LAMP test for Mycoplasma, given that a commercial PCR test is now available (PathoProof, DTS).

1d (ii) Projects with Strep uberis as the sole pathogen of interest

Genes associated with the virulence of *Strep uberis*. RMIT (Margaret Deighton)

Prof Deighton's group in Biotechnology and Environmental Biology at RMIT was able to isolate 2 distinct clusters of *Strep. uberis* - one group associated with clinical and subclinical mastitis and a 2nd cluster associated with low cell count cows. Part of this work was reported by Tomita T *et al* (2008)[9], viz:

Multilocus sequence typing analysis of *Streptococcus uberis* identified a cluster of isolates associated with clinical and subclinical mastitis and a cluster associated with cows with low somatic cell counts in their milk. Specific groups of genotypes (global clonal complex [GCC] sequence type 5s [ST5s] and GCC ST143s) were highly associated ($P = 0.006$) with clinical and subclinical mastitis and may represent a lineage of virulent isolates, whereas isolates belonging to GCC ST86 were associated with low-cell-count cows. This study has, for the first time, demonstrated the occurrence of identical sequence types (ST60 and ST184) between different continents (Australasia and Europe) and different countries (Australia and New Zealand). The standardized index of association and the empirical estimation of the rate of recombination showed substantial recombination within the *S. uberis* population in Australia, consistent with previous multilocus sequence type analyses.

[9] **Takehiro Tomita, B Meehan, N Wongkattiya, J Malmo, G Pullinger, J Leigh, and M Deighton. 2008.** Identification of *Streptococcus uberis* multilocus sequence types highly associated with mastitis *App Environ Microbiology* 74(1): 114-124

Subsequently, Dr J. Malmo has collected around 100 quarter samples from low cell count cows for the group to work with. The aim of one current post-graduate project is to study the cytokine response by bovine mammary epithelial cells to the two different groups of *S. uberis* ("virulent" and "commensal").

Differentiating between existing and new infections of *Strep. uberis* RMIT (Margaret Deighton, Jakob Malmo)

In 2007/08, Dr Malmo collected the clinical mastitis records for 6 of his dairy farm clients. Participating farmers collected aseptic samples from as many clinical cases as possible and froze the samples. Samples were submitted to Prof Deighton's lab for culture and, when *Strep. uberis* was isolated from repeated cases in the same cow, the isolates were subjected to Pulsed-Field Gel Electrophoresis. The key goals were to examine the data for any evidence of cow-to-cow transmission and to determine whether cases of *Strep. uberis* that recurred were due to failure of treatment, or were due to new infections. A poster describing this work was presented at the July 2010 meeting of the Australian Society of Microbiology[10].

In summary:

- Most isolates had different PFGE patterns.
- 59 (28 %) isolates were from cows with more than one infection over a 12 months period.
- The wide variety of *S. uberis* strains found was consistent with an environmental source of *S. uberis*, resulting in infection with multiple *S. uberis* PFGE types. However, there was also evidence of cow-to-cow transmission, or acquisition of the same strains from a common environmental source.

1d (iii) Other mastitis-related projects listed in DMF table

Benefit Cost Analysis of using teat sealants. Warrnambool Veterinary Clinic.

Dr David Beggs, of the WVC, has developed a model to test and to demonstrate the economic benefits of the excellent results published by Runciman et al. (JDS. 2010, see later) showing that combined teatseal and dry cow therapy achieved a 65% - 70% reduction in clinical mastitis in the following lactation. This model is available at http://www.wvc.com.au/teatseal and has been distributed to most dairy veterinary clinics by Pfizer, who purchased the right to the model from the WVC for promotional purposes.

Dr Beggs (pers. comm. to G. Mein) says he has never seen a single product have such a major impact on mastitis. The WVC now has several 600+ cow dairies with low mastitis rates and BMCCs below 200,000 cells/mL for the first time in their history. Dr Beggs is less certain about the value of using teatseal in heifers, however, particularly because when it is used in cows, the heifer mastitis rate seems to be reduced presumably as a result of reduced cross-contamination.

[10] S. Abureema, J. Malmo, M. Deighton. 2010. Characterisation of Strep uberis from bovine mastitis using Pulsed-Field Gel Electrophoresis.

Heifer mastitis incidence in the Macallister Irrigation District and risk factors involved.
Dairy Australia (Dr Lauren Clyne, veterinary intern. Supervisors: J. Malmo, P. Mansell)

Data collected from 20 herds in the MID in 2009 have been analysed to determine the proportion of heifers becoming infected at different stages of lactation, cure rates during lactation and the economic losses associated with mastitis. In addition, the study seeks to identify management factors that may be associated with increased or decreased incidence of mastitis in heifers. About 10% of the 2000 heifers in the study herds developed clinical mastitis in at least one quarter in their first lactation. Starting in the spring of 2010, individual milk samples from every clinically affected quarter of heifers are being cultured to determine the types of organisms causing infection. Samples will be taken from sub-clinically infected heifers at their 1st or 2nd herd test.

Better understanding of liner compression to control its effects on teat end condition
Doug Reinemann (University of Wisconsin) and Graeme Mein

New infection rates are reduced by pulsation characteristics that provide effective teat massage. 'Effective pulsation' involves much more than the present industry pre-occupation with recording and analysing pulsator rate and ratio. The key factor is the cyclic compression applied by the closed liner to the teat tissues to overcome the dilating and congesting effects of the milking vacuum. The main variables affecting liner compression are: teat size and shape; geometry and mounting tension of the liner; physical properties of the liner material; pressure difference across the liner barrel. Inadequate liner compression will result in teat tissue congestion during milking. Excessive liner compression will result in an increase in hyperkeratosis (roughened teat ends). A recent summary of this work is given in Reinemann, 2010[11]

1d (iv) Other recent mastitis-related projects conducted in Australia but not listed in the DMF table

Five research projects, conducted under the Countdown banner with contributions from DA, NHIA (Dairy Herd Improvement Fund), ADHIS and Uni of Melb social research, have contributed to important farm-level outcomes in mastitis control, viz:

Mastitis Economic Model. An important feature of getting industry engagement (farmer and factory) in mastitis control was deemed to be a more explicit understanding of the losses incurred (eg, how low would it be worth hunting for cell counts) and what part of the control process had the most impact. The Countdown model in 2002 demonstrated the economic benefits of achieving different mastitis control status, and also encouraged a focus on particular control elements (eg, a re-doubling of efforts in promoting post-milking teat disinfection and support for the utilisation of teat sealants at the Adviser Conferences in 2003 were based on the results of Countdown's mastitis economic model).

The Insights work. As part of the delivery of the Farmer Short Courses, farmers were encouraged and guided to develop their own Mastitis Action Plans. The Countdown

[11] Reinemann, DJ. 2010. Advances in machine milking: the influence of milking on teat condition and mastitis risk. International All Stars Mastitis Control Symposium, Melbourne, March 2010.

team felt it was really important to know what happened to the farmers' ability to plan/re-plan, and what, if any, impediments there were to maintaining mastitis control on farms. This was, essentially, research into the adoption of known technology – which fitted in with Countdown's assessment that the real barriers were about getting existing information about mastitis used to best effect by farmers.

Mastitis Focus. One of the findings from the Insights research was that farmers and advisers needed better ways to assess and monitor performance. A significant piece of research into best methods to measure and report New Infection Rates and other appropriate measures led to the development of a remarkably effective analytical and reporting tool for both farmers and their udder health advisers known as 'Mastitis Focus' (and also used in subsequent research by Penry & Mansell, see ref. 15).

Achieving Sustainable Improvement. Another key issues raised by the Insights research was the need for on-going input by advisers on the elements of risk management for mastitis control. The next research effort here was around the adviser business capacity to deliver. Although the 'CountdownMAX' product that was envisaged from this research has not been fully implemented yet (mainly because the Countdown project was winding down due to lack of on-going funding by then), it has been incorporated into the InCalf project with apparent success.

Genetics and mastitis. After their research on factors influencing the genetic Australian Profit Ranking, ADHIS have calculated and included mastitis (based on cell count) in their ABVs and indexes. Mastitis resistance is now a breeding objective that farmers can pursue through the Good Bulls Guide.

Herd prevalence of *Streptococcus agalactiae,* assessed by detection in bulk vat milk using polymerase chain reaction (PCR). P. Mansell & G. Browning. University of Melbourne, Department of Veterinary Science.

A survey of dairy herds across Australia was undertaken to investigate the herd prevalence of *S. agalactiae*. Several milk processing companies were asked to provide a single bulk tank milk sample from 10 – 20% of their supplier herds. In total, 571 herd samples were provided by factories, either directly or through a third party milk quality laboratory (DTS). This represented approximately 7% of the dairy herds in Australia at the time (2008).

S. agalactiae was identified in 39 (~7%) of the samples. Within processors or processor regions, the proportion of samples that tested positive ranged from 0 to 24%. The highest proportion of *S. agalactiae* positive herds were from New South Wales or Queensland. At least one herd tested positive for *S. agalactiae* in 9 of the 11 processor regions.

New knowledge from research on Shorter Milking Times (SMT)

Research conducted at Ellinbank DRI showed that early termination of milking could save up to 35% of normal milking time of slow milking cows with no adverse effect on their daily milk yield (averaging up to 26 L/d), milk composition, teat condition or cow behaviour (Clarke *et al*. 2004)[12]. Subsequent studies (Clarke *et al*. 2007)[13] indicated that early termination of milking had no significant effects on incidence of clinical mastitis, sub-clinical mastitis or average SCC in healthy quarters or in quarters sub-clinically infected with either *S. aureus* or *Str. uberis* mastitis pathogens. These relationships have not been examined in *Str agalactiae* herds, however.

The major practical outcome of these studies by Clark et al. has been a marked reduction in the time required to milk herds in which the SMT guidelines are implemented. The combination of a pre-set maximum milking time and an end-point determined by ACR threshold (whichever comes first) has great potential to shorten milking times per herd by reducing or eliminating the bottlenecks caused by slow-milking cows.

The use of an internal teat sealant in combination with cloxacillin dry cow therapy for the prevention of clinical and subclinical mastitis in seasonal calving dairy cows

D. Runciman, J. Malmo , and M. Deighton, 2010[14].

Cows (n = 2,053) from 6 seasonally calving dairy herds were enrolled in a trial to compare the efficacy of 2 dry cow treatments. Cows received either a combination dry cow therapy of 600 mg of cloxacillin (CL) followed by an internal teat sealant (ITS) containing 2.6g of bismuth subnitrate in all 4 quarters immediately following their final milking for the season, or only an intramammary infusion of 600 mg of CL. All cases of clinical mastitis were recorded and cultured during the first 150 d of lactation in each herd. Cow somatic cell count (SCC) was measured between 7 and 50 d postcalving. Analysis of the relative proportions of cows with clinical mastitis was performed at both the udder and cow levels. The relative risk (RR) of clinical mastitis diagnosed within 21, 30, and 100 d of calving in a gland treated with the ITS-CL combination was, respectively, 0.30 [95% confidence interval (CI) = 0.21–0.44], 0.39 (0.28–0.53), and 0.58 (0.46–0.75) that of the CL group.

The ITS-CL combination of dry cow treatments was associated with a reduction in subclinical mastitis [SCC ≥250,000 cells/mL; RR = 0.80 (95% CI = 0.65–0.98)] when compared with treatment with CL alone. The use of an ITS in combination with CL dry cow treatment was associated with significantly lower clinical and subclinical mastitis in the following lactation, with a greater difference found in cows that had a history of subclinical mastitis in the previous lactation.

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[12] Clarke, T., E.M. Cuthbertson, R.K. Greenall, M.C. Hannah and D. Shoesmith. 2004. Milking regimes to shorten milking duration. J. Dairy Res. 71:419-426.

[13] Clarke, T., D. Cole and R.K. Greenall, M.C. 2007. Shorter Milking Times research program: Technical information package for advisers, December 2006. DPI, Melbourne, 3000. ISBN 978-1-74199-065-2

[14] D. J. Runciman, J. Malmo , and M. Deighton 2010. J. Dairy Sci. 93 :4582–4591

New mastitis infection rate analysis in Australian dairy herds utilising a novel individual cow cell count reporting system. JF Penry and PD Mansell.[15]

This paper reports an analysis of new infection rate (NIR), based on the cell count algorithms in Countdown's Mastitis Focus report, for a 2-year period in 400 randomly chosen herds from the ADHIS milk recording database. Selection of herds was weighted according to the total herd numbers in each dairying district. A new infection is assumed if a previously uninfected cow had a cell count above 250,000 cells/ml at the end of each study period. In this study less than 8% of herds had clinical case information available for the calculation of NIR along with ICCC data.

Results showed a mean monthly NIR of 5.3 and 5.0 for 2007/08 and 2008/09 respectively. Clearly, these NIRs are well above the recommended 'trigger level' of 2 infections per 100 cows per month for investigative action, as outlined by Australia's national mastitis and cell count project. The CD project also has a nominated trigger level of 15% for investigation based on the proportion of first lactation animals infected during a 12 month report period. This trigger level was exceeded by the mean calculated NIR in both 2007/08 (19.1%) and 2008/09 (15.1%).

Additional mastitis studies initiated and managed by Dr J. Malmo, MID

1) As a follow-up to his work with DTS on 40 dairy farms in the Macalister Irrigation District, Dr Malmo is collecting clinical mastitis data from 15 of these herds and asking farmers to submit milk samples from as many of these clinical cases of mastitis as possible. This will continue until around November 2011, the aim being to collect 12 months of data on the incidence of clinical mastitis on a range of farms in the MID and of the pathogens associated with these cases of clinical mastitis.

2) Evaluation of an intensive treatment protocol to be used in the treatment of recurrent cases of mastitis.

Clients of Dr Malmo's Maffra practice often ask what can be done with cows returning to their 3rd case of clinical mastitis. Culling is not a popular option for farmers although, in many cases, it may be the only approach. One client commented: 'We have been submitting milk cultures for a long time and mostly finding Strep. uberis, but we do not appear to have progressed in any way with respect to treatment of some of these cases'.

Because there is some evidence to indicate that extended duration of treatment may lead to better cure rates, Dr Malmo intends to look for clients who are willing to undertake an extended intensive treatment protocol that involves: daily intra-muscular a/b for 4d; daily intramammary a/b for 8d; milk with-holding period of 12d from start of treatment.

[15] Proc. 5th IDF Mastitis Conference, Ed: JE Hillerton, Christchurch, NZ

1e. Current gaps in our scientific knowledge about mastitis

1e(i) Countdown list of high priority areas for further research

Starting from the time when the Technotes were first produced in 2000, each Technote has included a short review of relevant scientific information and also an assessment of the research needs, as perceived by Countdown's team of scientific advisers, with priorities allocated as High, Medium or Low. The perceived needs that were rated as High priority in 2000-2003 are listed below, together with my brief additional comments.

TN 5.2 *It would be worthwhile to evaluate in-line conductivity or other automated means that reduce the labour required to detect clinical mastitis cases.*

GM: This process has begun but it remains a 'work in progress' (for example, see Kamphuis et al. 2008, J. Dairy Sci. 91:4560; Claycomb et al. 2009, NZ Vet J. 57:208)

TN 5.3 *It would be worthwhile to evaluate the effect of teat preparation on environmental streptococcal infections in Australian conditions. Similarly, a comparison of flamed udders, "one-step preps" and techniques currently used in the industry could be assessed in a pre-milking hygiene trial.*

GM: This remains a worthwhile intention and a high priority. Unfortunately, adoption of the US-style pre-milking disinfection protocol is very labour intensive and few if any farmers are prepared to try it. A few farmers who have heard about pre-milking teat disinfection simply spray some iodine over dirty teats (highly unlikely to be efficacious, according to J. Malmo!!). If a pre-milking teat disinfection technique could be developed that were effective and could be applied with the minimal labour available on the typical Australian dairy farm, it would certainly be worth evaluating [also see comments below re FAQ on Pre-milking teat disinfection].

TN 6.1 *Further development of practical milking time tests and guidelines would be helpful. Training for veterinarians and technicians is essential. Development and evaluation of automated warning systems for faults and service requirements are recommended.*

GM: The first part has been accomplished now. Relevant publications include: 'Performance tests of milking machines' Countdown Downunder, 2004; 'Evaluation of Milking Performance' IDF Bulletin, 2005 (Authors: DJ Reinemann, M Rasmussen, G. Mein, P. Reugg).

The second part needs urgent attention (especially training for technicians).

The third part remains desirable and is still needed.

TN 7.6 *More efficient methods of dispensing teat disinfectants (e.g. better spray nozzles and automatic spray units) are required to improve teat coverage and minimise labour.*

GM: Application of disinfectants in foam has produced excellent results in UK. The development of an effective, robust and reliable automatic spray unit remains elusive, however.

TN 27.1 *Practical solutions to mud problems need to be demonstrated locally for many areas in Australia.*

GM: Perhaps this issue should be addressed in the new TN on Str uberis?

FAQ Pre-milking teat disinfection. *The effects of pre-dipping or pre-spraying teats on environmental streptococcal infections and Staph aureus mastitis under Australian conditions should be explored, with special attention to strategic pre-milking teat disinfection in the first few weeks after calving.*

GM: A small NZ study by Woolford, Williamson & Lacy-Hulbert (unpub, 2006) did not show any significant positive effects from the application of pre-milking teat spraying in addition to post milking teat spraying. This study was limited to three herds that, in hindsight, were found to have had relatively low *Strep uberis* new infection rates at calving. The work was discontinued when Murray Woolford died in 2006. According to John Williamson, there may be a case for strategically pre-spraying teats of the colostrum mob, especially in *Strep uberis* problem herds.

FAQ Teat sealants. *It is important to understand practical issues that determine the success of using teat sealants in Australian dairying systems. A model that enables advisers to assess the cost benefit of dry cow strategy options in individual herds would be useful.*

GM: Excellent new results have been published in JDS by D. Runciman, J. Malmo & M. Deighton in 2010 (see ref. 14) and a model developed by D. Beggs (see http://www.wvc.com.au/teatseal).

1e(ii) Other gaps that were not addressed in Countdown's original list of high priority areas

Knowledge gaps re prevention/management of ***Strep. uberis***

Preliminary discussions between members of the reconstituted Countdown team, in Nov 2010, lead to the following short-list of questions or gaps in current knowledge points about *S. uberis.*

- What is the best antibiotic option (for clinical and subclinical)?
- Role of extended therapy and increased frequency
- Cost-effective options for Rx high cell count cows
- Hygiene of teats at cups on (Dry OR Clean OR are both necessary?)
- How clean does the environment need to be? When are new infections most likely to occur? Up until the time of calving (the circle broken with Teatseal). What about the infections which start 4-6 months into the lactation?
- Variation in virulence.
- Routine of pre-milking teat disinfection.
- Teat spraying during transition (prior to calving).

This short-list probably will be refined as part of the current, high-priority task of drafting the proposed new Technote. Meanwhile, Dr J. Malmo has provided the following brief comments on some of the individual points in Countdown's short-list.

Clearly, the review and development of this new Technote remains a 'work-in-progress'. A working draft by the primary authors (Malmo and Penry) will be available on or before mid-February, 2011. Further input from a wider group of experts (including from NZ) is planned for late February.

- **What is the best antibiotic option (for clinical and subclinical)?**
- **Role of extended therapy and increased frequency**
- **Cost-effective options for Rx high cell count cows**

  JM: Others may well disagree, but I do not think we have the information available, at least with respect to the range of drugs we have at our disposal, to answer these questions. I see this as a major problem, hence the small project on intensive treatment protocol for recurrent cases of mastitis that I am trying to implement on farms in the Macalister Irrigation District.

  I have tried a similar, but slightly less intensive, treatment protocol for high cell count cows. The problem is that the extended with-holding period for milk following extended therapy makes treatment a very expensive option - perhaps should we should be looking at a more intensive treatment for recently infected high cell count cows at the time of drying off?

- **Hygiene of teats at cups on (Dry OR Clean OR are both necessary?)**

  JM: See my earlier comments - the main problem is limited labour availability on many dairy farms so the ideal would be an automated system of cleaning and disinfecting teats prior to cup application

- **How clean does the environment need to be? When are new infections most likely to occur? Up until the time of calving (the circle being broken with Teatseal). What about the infections that start 4-6 months into the lactation?**

  JM: Available evidence indicates that many of the infections that occur in the 1st month of lactation are due to infections picked up either over the dry period or at the point of calving - hence the value of Teatseal. The ones that start 4-6 months into lactation may occur as a result of the exposure of the teat end to *Strep. uberis.* In very hot conditions cows may be 4 months into lactation, but stand together under trees or in muddy areas which may well predispose them to infection.

- **Variation in virulence**

  JM: We are starting to get some information on strain differences within *Strep. uberis*, but we need to know a lot more about the ability of some strains to become more cow adapted and whether or not they become more difficult to treat. If they are more difficult to treat, then what are our options?

- **Teat spraying during transition (prior to calving).**

  JM: Teat spraying during transition may be a practical proposition on some farms and I believe there are some papers that show that this can reduce the risk of mastitis at the time of calving. Similarly, there is the work of Compton *et al* which showed that simply removing calves from the cows every 12 hours, and commencing milking the cows immediately, reduced the risk of clinical mastitis considerably. We need to review the work and see whether it may be applicable and/or practical in our situation.

Application of Shorter Milking Times (SMT) in herds with *Str agalactiae*

Early removal of clusters (based on SMT research) should not be recommended in herds where *Str agalactiae* is present because, as far as I am aware, it has not been trialled in any herds infected with this pathogen. According to some early publications, there is a risk that SCC and incidence of clinical mastitis will be increased by incomplete milking of cows infected with this pathogen. A further short study is essential to resolve this issue with confidence.

Importance of Mycoplasma mastitis in Australia

It is interesting to note that the Countdown Technote series contains no more than a passing reference to *M. bovis* (in a FAQ sheet on bacterial identification). Although this lack of emphasis seemed appropriate when the Technotes were first produced in 2000, it might be necessary to include more detailed advice on Mycoplasma mastitis in one of the new electronic Technotes. If so, adequate material is readily available from the USA NMC library of technical publications (for example, see: Udder Topics, NMC newsletter, October 2009. 'Look for Warning Signs to Prevent and Control Mycoplasma', included in this review as Appendix 1).

The 2011 annual meeting of the US NMC includes a short course on 'Mycoplasma Mastitis - New Findings and Improved Control Strategies'. Instructors for this course are Larry Fox, Washington State University, Pullman, Washington; and Allan Britten, Udder Health Systems, Bellingham, Washington. The course has been promoted as 'an opportunity for participants to review the scientific evidence that has been produced on this important dairy health problem. The risk factors of the disease, prevention and control (including vaccination), and future outcomes, will be addressed. New methods of diagnosis of mycoplasma mastitis will be discussed.'

2. Underpinning technologies that should be developed and implemented to address mastitis issues.

2a. Resources (skills and infrastructure) available in Australia that could contribute to development of the mastitis knowledge-base.

The various projects outlined in section 1d reveal a surprising amount of research activity in Australia - and some useful progress – that has contributed to the national mastitis knowledge-base during the last decade. Notable contributions include the social research projects conducted under the Countdown banner, the Shorter Milking Times research outcomes, and the remarkable reduction in new infection rates associated with the use of Teatseal at drying-off.

However, Section 1d also reveals a depressingly piecemeal approach to mastitis research throughout the last decade. This disparate collection of relatively small, 'opportunistic' projects reflects the lack of a coherent national strategy for mastitis research combined with a chronic shortage of research funds (and research personnel). It is interesting to note that a significant contribution to the limited research funding – and research activity - has come from private veterinary practitioners who are searching for practical solutions to particular mastitis issues, eg, from J. Malmo (Maffra), J. Penry (Camperdown VC), D. Beggs (Warrnambool VC).

The Countdown project was revived and re-constituted in 2010, with limited funding from Dairy Australia. Examples of the new team's contributions to the mastitis knowledge-base include:

- Initiation and management of an industry survey and analysis of mastitis and milk quality problems as perceived by Australian milk processors, dairy farmers and their specialist advisers (see DMF Report, Animal Performance report (Strategy 3, Milk Quality & Milk Harvesting, October 2010).
- Analysis of new mastitis infection rates (NIR) in 400 dairy herds using data derived from the Countdown 'Mastitis Focus' report. The disturbing results, presented by J. Penry & P. Mansell (2010), show that Australia has a long way to go to get average NIRs below current target levels recommended by Countdown or to encourage Australian dairy farmers to keep reliable records of their clinical mastitis cases.
- Organisation and management of the highly successful 'International All-Stars' Mastitis Control Symposium held in Melbourne, March 2010.

In addition, two members of the new Countdown team (P. Brightling and A. Hope) together with Dr R. Nettle (U of Melb) and S. Coates (DA) produced an internal report for Dairy Australia in June 2010[16] which proposed a new approach to the process of RD&E – the spectrum of thinking / organising / doing / reflecting ... that might lead to better overall RD&E outcomes for farmers. A copy of the executive summary is included as Appendix 2.

Their basic proposition is that the approach of 'do research' (get a technology) and have a 'route to market' for that research is unlikely to be the most effective. The research needs to

[16] Development-led innovation: a new model for operationalising RD&E
P. Brightling, A. Hope, R. Nettle. Report to DA, June 2010

fit within the logic of an overall 'route to change'. For example the SMT research (described in section 1d(iii)) made good sense within the context of the national CowTime project – where the big picture of activities / efficiencies within the shed were the focus, and SMT provided a vital bit of technological and scientific knowledge in the broad picture. An overall route to change was constructed (and would have continued if CowTime had continued to be funded).

Ideally, mastitis research should fit into an overall change-management framework – in which research asks the questions that the change-management program needs – and the change-management program adapts with feed-in from the research. For example, there will be key elements around *Strep uberis* that we need to know but don't know yet. If a research investment is focussed on providing this, the outcome for farmers and advisers can be far more effective.

Individual, piecemeal research components don't have anything like the same chance of contributing to real change for farmers without having the program for change surrounding and supporting them.

The D and E activities of the previous Countdown project were guided by an informal industry group known as the Australian Mastitis Advisory Council. Assuming that a similar industry Council could be established again now, it would offer the best potential to act as the national 'centre' for overseeing the development and co-ordination of a coherent, national infrastructure for mastitis R, D and E.

2b. Strengths and weaknesses of the current skill-base and how the existing skill-base could be utilised more effectively.

The main strengths of the current skill-base reside in the sheer number and diversity of individuals and organisations with a particular interest in minimising mastitis on farms, in keeping cell counts low for marketing purposes, and in maintaining both the image and reality of a high-quality milk supply in Australia. The list includes farmers, veterinarians, milking machine companies and individual technicians, milk processors and their field officers, pharmaceutical companies, teat disinfectant and detergent suppliers, analytical/bacteriological laboratories, and training organisations such as the NCDEA.

The main weaknesses include:

i) the great variation in level of knowledge and skills of individuals across the spectrum described above - for a variety of reasons including the rapid increase in use of paid labour on Australian farms, loss of skilled personnel to other non-farm industries during the prolonged period of drought in southern Australia, loss of momentum in the Countdown project due to lack of funding in the last few years;

ii) the depressingly small number of individuals at Australian universities or in State departments of primary industries with an active interest in R, D or E involving mastitis. The obvious reason is the almost complete lack of discretionary funds, opportunities for grants or availability of scholarships.

The existing skill-base could be utilised more effectively by:

- strengthening and revitalising regional networks of specialist advisers – especially the core networks comprising the local veterinarian, machine technicians and factory field officers;
- decisive action to resolve the fundamental weaknesses in the milking machine technician sector;
- provision of targeted training for factory field officers in trouble-shooting problems of milk quality or mastitis on farms;
- ensuring that training courses offered by the NCDEA for farmers and milking staff are current, technically sound and well-delivered;
- provision of one or more scholarships for selected post-graduate projects that will add to the knowledge-base on mastitis.

The first four of these five initiatives are included in the list of tasks for the newly-funded Countdown team, albeit with very limited funding from DA.

2c. Improving the existing skill-base to take advantage of new technologies and management practices

Two developments in automation technologies – rapid automated tests for mastitis pathogens; and in-line sensors for monitoring udder health during milking – have the potential to substantially improve mastitis management on Australian dairy farms.

i) Rapid automated tests for mastitis pathogens

Several organisations or international commercial companies are developing rapid automated tests at present. One of the most comprehensive sets of rapid tests, known as the Pathoproof Real Time PCR Mastitis testing system, will be launched officially in Australia in March 2011. This system is claimed to have five advantages over traditional bacteriological culture methods:

- speed to a reportable result - as the test procedure takes only 4 hours, the time to reporting results can be reduced to 24-36 hrs with good transport logistics;
- the PCR method can identify (and quantify) pathogens even if they are dead or growth-inhibited (cf. as many as 30% of samples return a result of No Growth using traditional bacteriological culturing);
- the Pathoproof is claimed to have excellent sensitivity and specificity for all of the major mastitis pathogens found in Australian herds;
- the system is claimed to provide up to 12 bacterial identification results;
- the PCR method allows quantification of the individual species present, thereby simplifying the task of trying to determine the dominant pathogen in individual herds or selected groups of cows.

Because the PathoProof system is being launched in conjunction with Dairy Technical Services, there will be a potential sixth advantage for Australian dairy farmers and their veterinarians – ie, a major streamlining of the logistics of sample collection, transport and reporting. It is quite likely that the DTS organisation, together with its team of experienced veterinary advisers, has already figured out their strategies, logistics and interpretation of results for veterinarians and farmers.

At this stage, there are no early indications or expectations of a likely market failure. Nevertheless, it is possible that some specialised training for regional veterinarians, some independent oversight and/or targeted funding might facilitate the introduction of this new technology and, thereby, help the development of a substantially faster, more reliable and cheaper pathogen identification service for the Australian dairy industry.

ii) In-line sensors for monitoring udder health during milking

Early adoption of in-line sensing systems for monitoring mastitis has had mixed results which may slow the adoption of future, more accurate systems. The following comments, from three experienced farm advisers, highlight critical shortcomings in the current application of sensing technologies:

- 'People have blind faith in some of these systems, without proper training it's almost a waste having them there.'
- '19 out of 20 farmers have no idea how to use their automated system and what to get out of it.'
- 'Maintenance is also an issue. I see farms with systems that are not being used because no one has been able to keep them working properly.'

Increasingly, farmers will be bombarded with information on different levels of automation and it is important that they have the resources to make informed decisions about what is likely to be appropriate for their farming system. In particular:

- The data generated must be reliable because trust can be lost very quickly, eg. by having too many false positive results that generate unnecessary work, confusion and frustration.
- Adoption of automated technologies requires development of sophisticated software and increasing the skills of farmers.

There is a need for independent advice but it is not clear who will be the supplier/s. The number of advisers with milk harvesting expertise, especially in states other than Victoria, is very limited. There is an urgent need for training at both technical and post-graduate levels to ensure that competent advisers are available to help farmers negotiate the coming automation/information revolution.

Active "succession planning" is essential to create a pool of competent advisers who can provide the type of independent advice and guidance that dairy farmers will need (or demand?) to help them navigate the automation/information revolution.

Following is an abbreviated version of a project conceived by an ad-hoc Expert Group which was constituted to review 'Automation and Information Technologies' as part of Strategy 4 (Investigate novel approaches to improve farm productivity) for the recent DMF Animal Performance review.

If this proposed project – or specific parts of it – are of interest to the Gardiner Foundation, then further discussions can be arranged with two of the key Victorian members of this Expert Group (Callum Eastwood, U of Melb; and Mike Larcombe, HICO Australia).

Theme 2. Maximising the benefits of automatic sensing systems

Core industry issue: Use of automatic sensing systems on dairy farms is expanding, but farmers and retailers are often operating in isolation when they install and use these tools. The potential benefits of such systems are sometimes oversold during the sale process, and the early use period provides many challenges for farmers due to technical teething issues and management adaptation. Currently there is a lack of industry investment in this area, to fill

the gaps left by the private sector. This theme is aimed at addressing these issues at an industry level.

Proposed activities:

- Build industry capacity for support of automation and IT. Retailers currently provide training to their clients but are limited by financial resources, location and availability of appropriately skilled trainers. There is a role for consultants and industry extension personnel to provide advice and training for farmers after the initial installation period.

- Clarify and promote agreed guidelines on practical reference standards against which new sensing systems can be evaluated. As an example, it is almost impossible to decide what are the 'right' performance measures by which different mastitis sensors can be judged or compared, because of the present plethora of 'true' gold standards for abnormal milk, clinical mastitis and subclinical mastitis.

- Review current automated technologies available for detecting cows requiring mastitis treatment and document the results for industry. The methods required for successfully implementing the appropriate technologies on farms should be identified so that these methods are incorporated within the herd management systems used on typical dairy farms.

Outcomes:

- Farmers are able to maximise the functionality of automatic sensing technologies in their particular system context.
- There is a real incentive for farmers to share on-farm data with the wider industry

2d. Recommendations for Australian dairy industry/stakeholder engagement and strategy towards mastitis

Perhaps the most cost-effective way to achieve industry/stakeholder engagement would be to conduct a short (half-day?) workshop involving representatives of organisations with a particular interest in mastitis and milk quality, plus selected researchers, veterinarians and advisers. The purpose of the workshop would be to outline the scope and results of this review, to seek critical comments on my recommendations and, importantly, to encourage industry stakeholders to accept 'ownership' for the agreed priorities and activities for further R, D & E on mastitis issues in the Australian dairy industry.

Such a workshop could be organised and conducted under a Gardiner Foundation banner or under a DMF banner with joint funding by the GF and DA.

Preferably, the workshop should be limited to not more than 15 people. Some of the participants could be selected from one or both of the Expert Groups who developed and delivered the chapters on Milk Quality and Milk Harvesting (for DMF Animal Performance, Strategy 3)[17] and Automation and Information Technologies (for DMF Animal Performance, Strategy 4)[18]. At least two farmers with vision, drive and a passion for resolving mastitis issues on Australian dairy farms should be included.

Ideally, these workshop participants could become the nucleus of a reconstituted and revitalised Australian Mastitis Advisory Council.

[17] ***DMF 3 Expert Group, MQ&MH****:* Chair Graeme Mein. Lisa Archer, David Basham, Dave Beggs, Mick Blake (apology), Pauline Brightling, Robin Condron, Rod Dyson, Helen Dornom, Callum Eastwood (apology), Greg Gilbert, Anne Hope, Darold Klindworth, Craig McRae (proxy for Andrew Gallagher), Jakob Malmo, Geoff Mathews, John Penry, Tony Seymour (proxy for Sylvia Vagg), Peter Younis.

[18] ***DMF 4 Expert Group, Auto & Info Technologies***: G. Mein (report co-ordinator); C. Eastwood, Uni of Melb; M. Larcombe, HICO Australia; K. Kerrisk, Uni of Sydney;)

Appendix 1: Look for Warning Signs to Prevent and Control Mycoplasma

Udder Topics, NMC newsletter, October 2009

Without a doubt, Mycoplasma mastitis is a challenging disease. No effective treatments are available, and cows sometimes shed *Mycoplasma sp*. intermittently – making it difficult to find the shedder(s).

According to Rubén González, Quality Milk Production Services associate director and senior research veterinarian, Cornell University, Ithaca, N.Y., the absence of cell walls and cell wall-associated proteins renders mycoplasmas resistant to the action of antibiotics that interact with these proteins. Consistently, research shows that mycoplasma infections do not respond to antibiotic therapy. There is no effective treatment for mycoplasma mastitis; thus, prevention and control are vital.

Prevention can be difficult because mycoplasma mastitis organisms are among the three major contagious mastitis-causing pathogens. (The other two are *Staphylococcus aureus* and *Streptococcus agalactia.*) Mycoplasma bovine mastitis is highly contagious. "The established contagious mastitis control practices of employing strict milking time hygiene that includes postmilking teat dip as well as identification and isolation of infected animals by separation and culling have been successful and is currently the method advocated to control mycoplasma mastitis outbreaks," explains Larry Fox, a professor in Washington State University's veterinary clinical services department.

Penn State University Extension Veterinarian David Wolfgang reports that infected animals can be carriers for life. Classic signs of mycoplasma mastitis are: failure to respond to treatment, multiple quarter infections, udder edema (often without fever), variable milk yield depressions, and udder secretions that can range from watery to very thick and clotted. "Once an animal is shedding *Mycoplasma sp*. in her milk, it spreads easily from cow to cow," Wolfgang states. "Well-trained milkers can be very helpful in identifying early infections."

Fox says that the single most important way to protect a herd from *Mycoplasma sp*. is routine bulk tank culturing. "This is a powerful early warning tool to help dairy producers detect the beginning of an outbreak," he comments. "Make sure a bulk tank culture is done on a herd at least monthly," Fox recommends. "Larger herds may want to test weekly."

One of the challenges with identifying *Mycoplasma sp*. is that it won't show up on a routine mastitis bacteria culture. Allan Britten, with Udder Health Systems in Bellingham, Wash., explains that to find out if mycoplasma mastitis is present, it needs to be diagnosed with a special (separate) mycoplasma culture. If you find Mycoplasma organisms in bulk tank cultures, then narrow down the list of cows that may be contributing to the problem and focus your culturing strategy on them. Culture all cows after freshening - a period when Mycoplasma organisms are frequently shed.

Fox notes that culturing for *Mycoplasma sp*. requires seven to 10 days of incubation to confirm a negative sample. Due to this delay in reporting, dairy producers should take precautions in handling milk from clinical mastitis cows until they receive Mycoplasma culture results. "When a positive cow is identified, consider it a potential threat to the whole dairy herd's health," Fox states. "One cow infected with Mycoplasma sp. may lead to more."

"A positive culture is very meaningful; a negative culture in a suspicious animal indicates the need for repeat culturing," states Wolfgang. Polymerase chain reaction (PCR) technology is available to detect Mycoplasma sp. "This technique is very sensitive and specific, and shows great promise as both a screening tool for bulk tanks and in some individual cow cases."

References:

- *Britten, A.M. 2006. Getting the Jump on Mycoplasma Outbreaks. Proc. 45th Annual Meeting of the National Mastitis Council, pp 212-216*
- *Fox, L.K. 2006. Mycoplasma Mastitis: It Just Won't Go Away. Proc. NMC Regional Meeting, pp 197-202.*

• *Fox, L.K. 2007. What's Up with Mycoplasma Mastitis? Proc. NMC Regional Meeting, pp 18-24.*
• *Gonzalez, R.N. 2006. Diagnosing Mycoplasma Mastitis. Proc. 45th Annual Meeting of the National Mastitis Council, p. 207-210.*
• *Wolfgang, D.R. 2004. Mycoplasma: An Emerging Problem in Dairy Herds. Penn State Dairy Digest, October 2004.*

Appendix 2: Development-led innovation: a new model for operationalising RD&E

Pauline Brightling, Ruth Nettle and Anne Hope, in consultation with Steve Coats
June 2010

Dairy Australia invests in the long-term success and sustainability of the dairy industry through its RD&E strategy. This strategy and industry capability is under review through an initiative known as Dairy Moving Forward. Ideas in this paper were developed to contribute to the push to increase the efficiency and effectiveness of RD&E. In any industry it is people who make innovation happen. New technologies provide the raw materials (knowledge, services or products) to innovate - to act creatively and adapt the resource to improve our situation. This report introduces a new way of thinking and acting around RD&E where development leads the innovation process. The new model highly values 'Research' (as the way of establishing the true potential of new technologies) and 'Extension and Education' (as the way technology reaches its target audiences). In contrast with existing industry models, it makes development of a '***route to change***' an explicit and necessary component of RD&E. The emphasis here is on 'Program Development' (as opposed to product development) and 'route to change' (not just 'route to market'). Program Development seems a natural focal point for any RD&E effort when the primary objective is to achieve widespread practice change. By definition development draws upon the existing body of knowledge in planning the 'route to change', identifies important knowledge gaps and prioritises what is needed to progress the situation. The quality of Program Development provides for the cohesion and effectiveness of activities in a domain. The challenge for the new way of acting is to put it into practice. The Development-led innovation model requires strong leadership of the development process, the commitment of organizations with commercial interests in the domain to ongoing, joint action and effective group engagement. If the dairy industry is interested in the new approach to RD&E the authors recommend it:

- actively develops its Program Development capacity; and
- makes the development task highly visible (reporting against outcomes of Program Development).

Advantages of adopting the Development-led innovation model

- Establishes a 'route to change'
- Builds a good understanding of the fit of the technology with farming systems and the enabling environment
- Aligns activities with the intention and worldview of farmers
- Promotes integration of new technologies with existing ones
- Encourages research around practical aspects of applying innovation in the commercial world
- Opens opportunities for businesses to fund aligned activities within their sphere of interest
- Provides a way for industry to work "across silos" (across different technical platforms and integrating RD&E activities)