SCIENTIFIC PROGRAMME:

POSTER ABSTRACTS (presenting author underlined):

MAKING CHANGES IN IMPROVING UDDER HEALTH: A VETERINARY PERSPECTIVE

T.J.G.M. Lam[1,2], J. Jansen[3], J.C.L. van Veersen[2] and R.J. Renes[3]
[1]GD Animal Health Service, Deventer, the Netherlands
[2]Dutch Udder Health Centre UGCN, Deventer, the Netherlands
[3]Communication Sciences, Wageningen University, Wageningen, the Netherlands

SUMMARY

The veterinarian is one of the most important advisors of farmers in the field of udder health. The practitioner has the tools to improve udder health if people are motivated to do so. Many farmers, however, are not convinced of the importance of udder health, or it doesn't lead to action from them. Many practitioners think they are unable to convince their clients of the possible profits from investing in udder health. There is something to gain here. This article describes which issues should be taken into account to achieve a more intensive cooperation and thus, better udder health. This is good for farmers as well as for practitioners, the former for reasons of economics, welfare and ease of work, the latter because it brings extra work. Farmers do not differ from other people, in the sense that their ability to learn will be enhanced by strategies that conform to their preferred learning style. Four styles: accommodator, diverger, converger and assimilator are discussed. The importance of internal and external motivation is discussed, and the main issues to influence motivation: personalization of messages, increase the farmers' frame of reference, and the use the power of farmers' social environment.

INTRODUCTION

Mastitis probably is the single most studied diseases in dairy cattle. Every year there are several scientific meetings on dairy cattle in different places in the world, where mastitis is either the main or one of the most important subjects. In these meetings much attention is given to further development of veterinary knowledge, while attention to the transfer of knowledge, although crucial (10), is much smaller. This year at the NMC, however, a valuable session, specific to mastitis control programs was organised.

All mastitis research workers, as well as organisers of mastitis control programs, or programs in which both are combined (9, 17) have the intention to improve udder health. That goal can be either defined as bulk milk somatic cell count (BMSCC) (15), clinical mastitis (3) or combinations of both (16). To actually improve udder health, whatever way defined, knowledge is of course important. Knowing how to solve mastitis problems, however, generally is not the bottle-neck in improving udder health (3). Knowledge-transfer is. This paper will provide some insights and opportunities for different approaches in knowledge transfer and motivation of farmers regarding udder health.

THE VETERINARY PERSPECTIVE

In todays veterinary practice, herd health management becomes more and more important. In many parts of the world dairy farmers don't make much money, so practitioners simply become too expensive to do handwork that others can do just as well. A number of traditional veterinary skills move to less expensive workers, and although denied by some, practitioners have no choice but to evolve to advice-oriented consultants (10) in order to stay in business. To be successful in that, knowledge from different disciplines must be integrated in recommendations and advice. To have successful herd health and production management programs, requires understanding of each farm as an integrated system (2). Apart from that, veterinarians need to have the skills to motivate farmers, to transfer knowledge, and to sell this advice as a product.

A complicating factor in this is that over the last decades, while veterinarians moved from treatment of clinical illness to disease prevention and from individual cows to herd level, the farmer moved to a more active and independent role. He is by no means any longer *obedient* to, or *impressed* by the veterinarian. This means that the practitioner really has to *convince* the client of the added value of his or her advice. Of course practitioners try to convince farmers of the importance of the advice given, generally by explaining the veterinary background to it. That is, however, not enough if you want the advice to be executed, and certainly not if you are looking for new clients for advice-consultancy work or new participants in an animal health program.

Many practitioners find it difficult to take this step to become more advice-oriented. Quite a few lack 'belief in own capacities' as recently described by Mee (13) in relation to providing specialized fertility service. In that same study, practitioners mentioned that when clients did not demand for programs this was a valid reason not to offer them. These practitioners did not consider themselves good 'salesmen' (13). They probably were right.

There are, however, also many chances. In our Dutch udder health project we found that dairy farmers consider their practitioner as their most important source of knowledge on udder health and as their first contact person in case of udder health problems (6). Practitioners, although many of them don't realize it, highly influence the opinion of their clients on animal health issues. We found for example, that if the practitioner considered a treatment schedule for mastitis important, farmers thought likewise. There is a lot of trust in the practitioner, and the practitioner sees many of his or her clients on a regular basis, giving them many opportunities for direct contact with clients and to show them how good they are at the job. The technical instruments to show this, to actually improve udder health at the herd level are available (3). When this knowledge is implemented at the practice level, for instance by using study-groups as we have done, participants also significantly improve udder health (9). There are, however, marked differences between veterinary practices in their success in improving udder health. As an example the BMSCC in herds participating in study-groups in one practice, compared to herds not participating and compared to the herds in the 20 control practices is shown in figure 1. For more details, refer to our paper presented at this years' NMC (9).

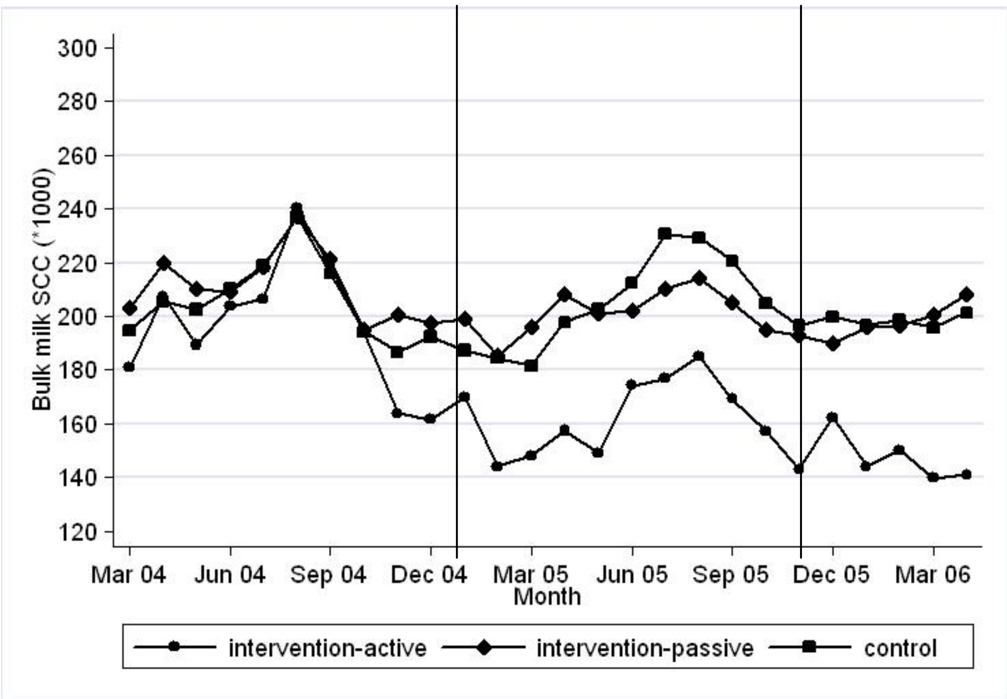

Figure 1. BMSCC in the herds of a veterinary practice. Herds participating in study groups (intervention-active; n = 36), herds not participating in study-groups (intervention-passive; n = 99) and herds in control practices (control; n = 2319) in the year preceding the program (2004) and during the execution of the program (2005-2006).

LEARNING STYLES

When giving advice, trying to transfer knowledge, one has to acknowledge that different people learn in different ways. In our opinion practitioners ask too few questions to be able to differentiate between farmers. It's hard to judge what is the best approach, if you don't know what the farmer wants. We tend to think that farmers' thoughts, aspirations and motivation (their 'mindset') and their behaviour are predictable, they are either 'in' or 'out'. They know what services we offer and they either call us to deliver those services, or they don't. To have them 'in', we tend to choose one approach: explaining the technical background of a disease. We too often assume that, once the farmer understands, he or she will act likewise. The background of this is comparable to the expert-lay discrepancy as described for food risks

(4). The expert-lay discrepancy is often attributed to a 'knowledge deficit' among 'lay people' (farmers), whereas reality is much more complex.

One of the approaches to differentiate between ways to present knowledge is the one of Kolb (7). Kolb differentiates four learning styles: accommodator, diverger, converger, and assimilator. The Kolb theory holds that an individuals' ability to learn will be enhanced by strategies that conform to the individuals' preferred learning style.

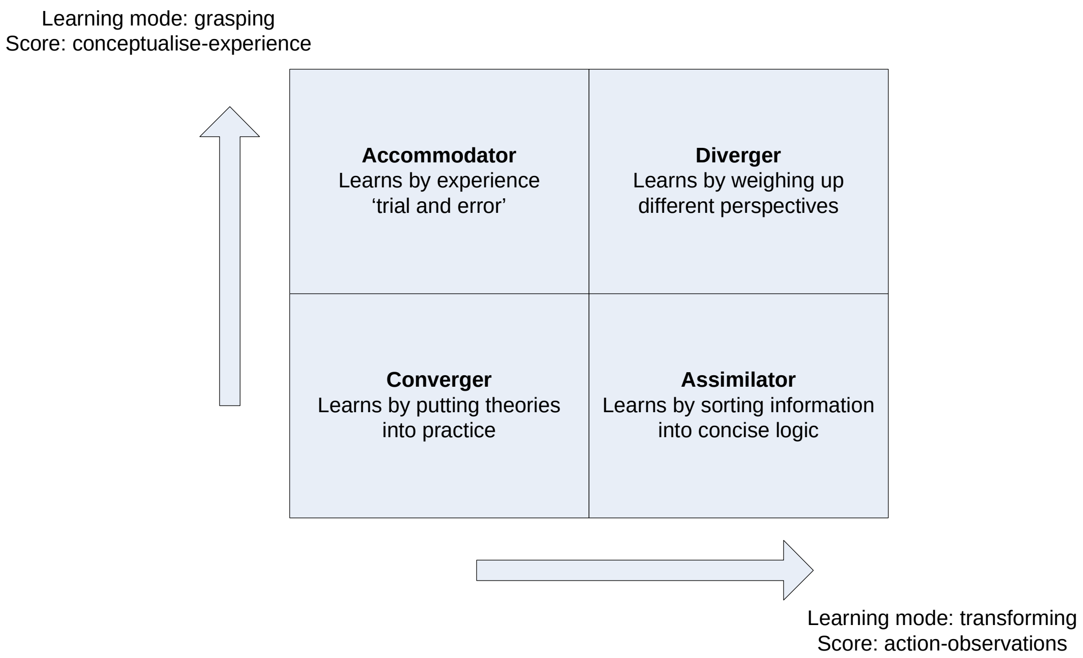

Figure 2. The learning styles according to Kolb, adapted from Paine (14)

An *accommodator* is very practical orientated, he or she learns by experience. An accommodator is the type of person who tries to get a machine running before reading the manual. The manual will only be read if really unavoidable, 'trial and error' is preferred. Offering the possibility to experiment actively and to have concrete experiences is a way to reach them (5). Specimens of products you want to be used, like for instance milking gloves or a CMT-test, may be picked up by them.

A *diverger* learns by weighing up different perspectives. A diverger is accessible to concrete experiences and reflects and analyses these experiences. They like to approach a problem from different angles and enjoy an environment that asks for creativity. Divergers appreciate analyses of problems in co-operation with others, discussions about the approaches people choose, *etc.* Excursions, trips to model farms or open door days as used by Reneau in Minnesota (15) can be good learning methods for them. All persons and organizations in the social environment, including organizations for agricultural and veterinary education, should express the same message. In that way conflicting information is avoided and the farmers' trust and motivation in the social environment will be better maintained.

A *converger* learns by putting theories into practice. He will start reading the manual and will follow it step by step. In the study-groups we organized (9) we experienced that farmers appreciated instructions on basic parts of routine work in animal health. Actions the practitioner would take for granted beforehand like, 'how to take a milk sample without contamination', 'where to inject a cow' and 'how to do a CMT' were found very useful, especially if applied with the cows in the barn. This can be interpreted as a mixture of a converging and a diverging learning style. Tools specific for convergers can be instruction cards on milk sample collection, CMT, milking technique, injections, and so on. Van Helden (5) describes that thinking in concepts and generalisations are important for convergers. In learning they prefer questions with only one correct answer. In knowledge-transfer the practical implications of the content should be clear right from the start.

An *assimilator*, finally, learns by sorting information into concise logic. The assimilator is the more scientific type. He or she appreciates observation and reflection to form conceptual ideas. Assimilators want to gather lots of information from different sources, they like self-study, and will gradually form an idea on the subject (5). The practitioner (or a study group) is only one source of information. Websites with technical information, articles in farmers magazines, information at dairy shows, agricultural education, information given by the dairy industry and farmers organizations will all be absorbed and weighted.

One would, perhaps, expect most farmers to be accommodators (14). However, a study on learning styles of sheep and beef cattle farmers in New Zealand showed that of 81 participants of study groups a surprising 50% expressed a preference for logical learning (assimilator) (20). It would be easiest in knowledge transfer if all people were alike, a wish that is often translated into practice. However, if one really wants to reach as many people as possible, all learning styles need to be given attention (5).

BEHAVIOUR

The evaluation of our udder health program (9) seems to imply that farmers participating in study groups generally are the ones that already performed above average before the start of the program. By making use of the means offered by the program, these farmers improve further. This is confirmed by the experiences described by the participating practitioners. As a result, by applying the knowledge available, it seems highly likely that we can improve udder health. However, it is difficult to get farmers to do so if they, for some reason, are not motivated. As such, the program does not seem to have the expected effect on farmers with mediocre or worse udder health status. Then the question arises: how do we improve the program in such a way that more farmers are motivated to participate in study groups or other udder health programs? To find an answer, communication and social psychological theories can be used.

Behavioural change can be induced by several policy instruments. Figure 3 shows different policy instruments and their effect on behaviour (11, 21). In this model behaviour (i.e. the implementation of mastitis control practices) can be influenced compulsory or voluntary. Compulsory behavioural change is facilitated by coercion such as regulations and restrictive provisions (21). In udder health programs the effect of milk quality legislation and control systems can be more or less subscribed to coercion. However, it is well known that compulsory behavioural change will probably only last as long as the coercion exist. Additionally, with respect to udder health, coercion can only be used in extreme cases and only for bulk milk parameters. Thus, a voluntary behavioural change is much preferred.

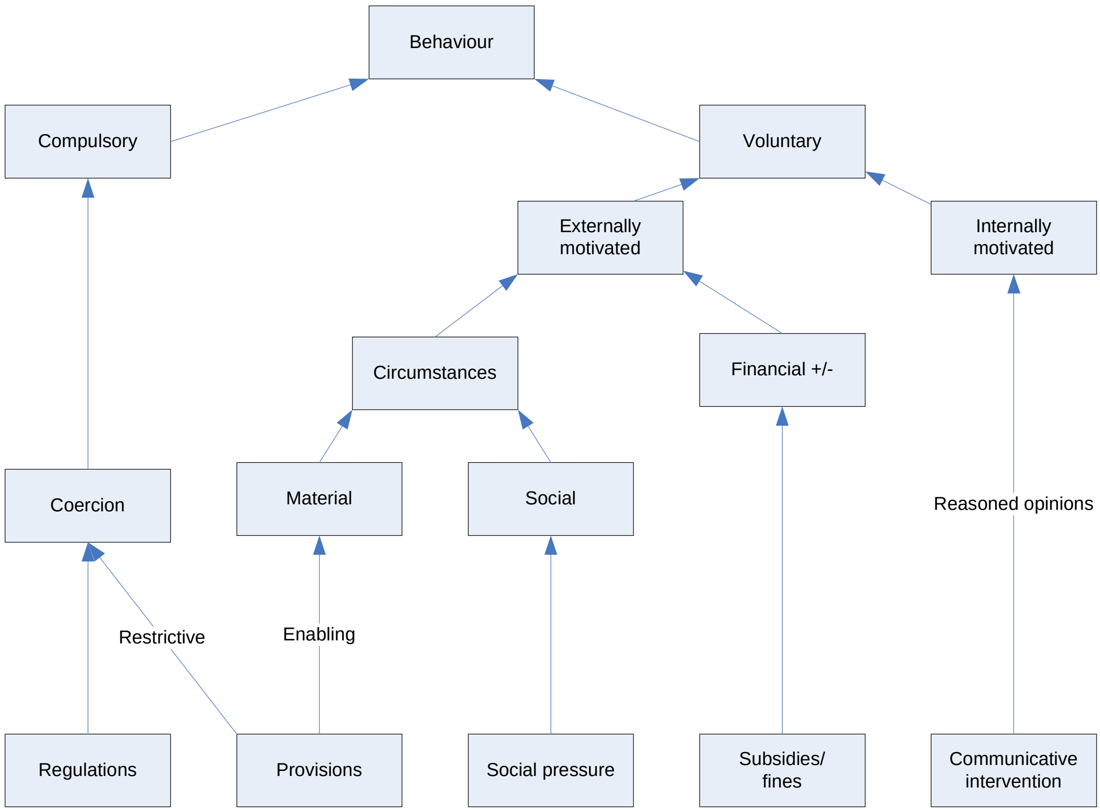

Figure 3. Behavioural change by policy instruments (11, 21)

Motivation is an important element in changing peoples behaviour. People can be internally and/or externally motivated. External motivation can be accomplished by financial means through bonuses and penalties related to BMSCC (18). Farmers are convinced that, when for instance they receive premiums for lower cell count, they will be motivated to react (6). A study of Valeeva et al. (19), however, showed that quality penalties tended to be more effective in motivating farmers to change their behaviour than quality premiums.

Internal motivation can be influenced by communicative intervention through reasoned opinions, such as persuading farmers by use of articles in magazines, lectures at informative meetings and in study groups, and discussions with the practitioner. Internal motivation is probably most effective in long-term behavioural change. However, to understand internal motivation of a farmer, we need to understand and anticipate on farmers' 'mindset' and the interaction of farmers with their social environment. A farmers' mindset can then be seen as a combination of what farmers want, know, believe and perceive regarding animal disease. As such, the mindset then could support the understanding of farmers' behaviour and the way this behaviour can be influenced.

Leeuwis (11, 12) developed a model about decision making of people based on a mindset (see figure 4) showing that what people do, or not do, depends on different factors, which are influenced by identity. The model shows that farmers make different decisions, based on the identity they have at that moment. For example, a farmer would make a different decision in his role as a father, than in his role as a farmer. This role or identity of a farmer and the related factors interact with the farmers' environment and can therefore also be influenced by communication strategies.

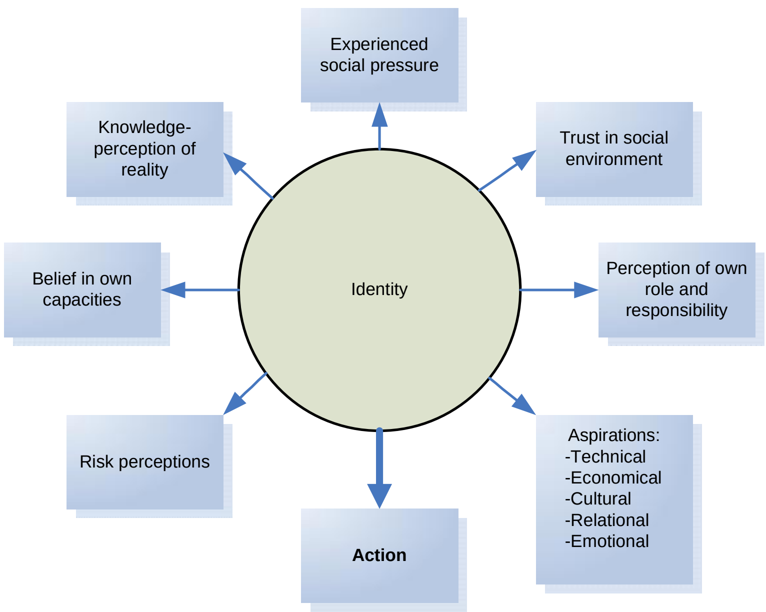

Figure 4. Composition of a mindset by flexible identities in interaction processes (11,12).

Analysis of factors influencing the mindset of farmers in relation to our udder health program showed that the Leeuwis model could be applied. For 'risk perception' a difference is found between the problem-level and the satisfaction level of BMSCC, on average 280,000 and 150,000 cells/ml respectively (6, 8). We found that only 27% of farmers managed to reach their satisfaction level, while 6% of the farmers exceed their problem level. The way farmers perceive risks plays a crucial role in this, where risk assessments are situationally sensitive expressions of personal value systems. Optimistic bias (it won't happen to me) as well as a lack of 'trust in the social environment' such as institutions and experts can be an obstacle in effective communication (4).

Evaluation of 'belief in own capacities' in the baseline survey showed that 27% of the dairy farmers think they directly know what the causes are when a mastitis problem occurs and 32% of the farmers in the survey think they know enough about mastitis to prevent problems (6, 8). These results suggest that about two-third of the Dutch dairy farmers feel insecure about actually dealing with mastitis problems. This corresponds with the findings on 'knowledge perception of reality'. Most farmers think they have sufficient knowledge about mastitis in general but that this knowledge is not always decisive in relation to their own situation (6, 8).

The positive results found in the study-groups (1) reinforces the fundaments of communication theories that 'experienced social pressure' by colleagues and social learning are important in persuasion. Additional factors explaining farmers' behaviour are 'perception of own role and responsibility' and 'aspirations'. Results from the baseline survey showed that most important farm aspirations are to get a high net return and to keep the farm management simple (6, 8). This can be conflicting with the messages in the udder health program. For example, farmers may perceive the application of extra preventive measures to be expensive or complicated. Realising that farmers are as diverse as other people, and that not all farmers are motivated to 'understand' would be a big step forward.

INTENSIFYING FARMER CONTACTS

In most programs to promote udder health, veterinarians play an important role. They have the knowledge and the access to the farmers. Veterinarians are able to improve udder health results of internally motivated farmers (9). However, it seems that veterinarians themselves find it difficult to motivate farmers who are not interested in the first place. There may be possibilities to intensify the contact with that group of farmers (13). Additionally, in a chancing agricultural world, the need for effective knowledge transfer and motivation of farmers increases. Currently, many udder health programs focus on expert-to-lay communication, including the perception that farmers have limited knowledge and that they will adopt the provided knowledge instantly once they understand the background. This misconception leads to communication programs which are one-sided and only attracts farmers with the accompanying learning style.

Motivation and behaviour varies between farmers, is quite unpredictable, context related and not easy to influence in a short period. As such, it should be acknowledged that it is inevitable that we need to use a combination of communication strategies to change farmers' behaviour. Additionally one has to anticipate the farmers' mindset regarding udder health. Nevertheless, the explanation of the farmers' mindset as presented in this paper shows key areas that can be focused on:

When developing programs on udder health, knowledge transfer and motivation play a major role, and one has to anticipate the farmers' (and veterinarians') mindset. The most important aspects regarding this mindset are:

(1) Personalization of messages: each farmer is unique and different and has his own aspirations, learning style, knowledge, social network etc.
(2) Increase farmers frame of reference and give feedback: ask questions, learn from each other, what is normal on this farm and why?
(3) Use the power of farmers' social environment: colleagues, family, feed advisers etc. Involve them in your communication.

First, personalization of the message is a concept that is well known in communication theories. When farmers are not convinced about the usefulness of the message for their individual case, they will not be motivated to further process the message. As such, the message of the udder health program needs to be personally relevant. The only way to make the message personal relevant is to acknowledge that farmers have different mindsets in different situations and to anticipate their mindset in communication strategies.

Second, when focusing on farmers' mindset, it seems that some farmers lack a realistic evaluating frame of reference about mastitis. Farmers seem to feel insecure about their knowledge and the translation of this knowledge into action. However, most farmers manage to stay below their own problem level of mastitis. This problem level can still be quite 'easy' to manage, probably because it is personally framed by their experiences and comfort rates rather than by a realistic frame of reference. Therefore, realistic information about problem levels could be very important in the communication towards the farmers. For example: When do you have a mastitis problem? When am I doing well? What is a good farmer? How can problems be solved? Are other farmers implementing mastitis prevention as well? Does that work? Questions such as these are immediately associated with providing feedback. Currently, farmers perceive little feedback about what they are doing. Newly implemented mastitis control measures or advice should have a follow up to reinforce the farmer's confidence that he is doing well. As such, the individual effort of farmers becomes more visible and could increase the perception of the own role and responsibility and directly personalizes the communication as well.

Third, social learning and social pressure seem to be very important in changing the farmers' mindset. Farmers may experience social pressure if a sort of 'national standard' in udder health management is set at a higher level. Articles in farmers' magazines, information at dairy shows, agricultural education, information given by the dairy industry and farmers organizations, social networks, and examples of 'good dairy practices' in 'open door days' in model farms may be helpful to support the udder health program in communication to farmers. All persons and organizations in a farmers' social environment, including organizations for agricultural and veterinary education, should express the same message. In that way conflicting information is avoided and farmers' trust and motivation in the social environment and the udder health program will be better maintained.

The practitioner is in an ideal situation to use this knowledge. In relation to the first two points, he or she knows each individual farmer, can ask questions to each of them, is able to know the farmer's frame of reference, is able to give feed-back to that based on a broad knowledge, is able to evaluate the advice given earlier, *etc.* The third point, the social environment, should partly be organized at a higher level. However, the local social environment is important too. Our impression in the Dutch udder health project is, that good evaluations and results are not only good for participants of study-groups, but also have an attractive effect on farmers that have not participated so far. Organizing successful study-groups in a practice seems to give some social pressure. Therefore, these evaluations and 'best practices' need to be communicated to all farmers. As such, feedback as well as a frame of reference is provided. In this way other farmers might feel they are able to improve their farms, and will be recognized for it.

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ADVICE – WHY IS SO MUCH LEFT OVER FROM LAST YEAR?

Brian Angell
ADAS, Gleadthorpe, Meden Vale, Mansfield, Nottinghamshire, NG20 9PF

SUMMARY

The British Mastitis Conference is testament to the importance of the subject to the industry. Although progress in developing prevention is seen as slow, the Dairy industry is not alone in believing new forms of agricultural technology or husbandry are not taken up sufficiently or fast enough. This is a paper about change: - What change is, what helps or hinders people changing, why the changes that we try and influence may not work out as we think, and what we as agents of change may need to do to help farmers adopt improved practices of mastitis management.

Getting all aspects of the technical solutions to line up with the wide variety of farmer aspirations, approaches to business and the complexity of the decision making process is a tall order. We have to look to the sciences of behaviour and communication for insight.

- Is our approach accessible to our target groups?
- Do we communicate in a form that can be readily understood?
- How can we ensure that we are seen as credible and believable?
- Are we sure what we are communicating is relevant and compatible with the farmers we try to influence?
- Does what we communicate fit with our understanding of the inherent knowledge and skill of our audience?
- How can we ensure that we tailor this closely with farmers' personal aspirations?

INTRODUCTION

The fact that we have an annual British Mastitis Conference is testament to the importance of the subject to the industry and its advisers as well as to the comment that "it is hard to be convinced that the UK has made any significant progress in preventing the disease for the last 15-20 years (8)."

The dairy industry in the UK is not alone in facing these issues. A few years ago extension agents in the USA identified a number of factors that they felt had hindered the assimilation of new agricultural technology:

- a perceived fundamental inability to demonstrate a linkage between economics and biology at the production level,
- limited movement away from a discipline based or single-factor approach to a broader systems approach for evaluating the potential impact of available technology affecting ability to understand cost benefit,

- instruction and demonstration of new technology within the controlled setting of a university research farm may not encourage farmers to adopt the technology for their farms, which have distinct and different resources,
- by failing to recognize and address the psychosocial component of technology adoption as part of the educational process, we have proven that generating knowledge isn't always synonymous with diffusing and adopting knowledge.(6)

All of these factors also have a part to play in relation to my subject today.

THE NATURE OF CHANGE

As Samuel Johnson once said: - “Change is not made without inconvenience, even from worse to better!” In this adage the sage touches on the profound truth that all change requires some form of movement, which costs us in some way, even when the outcome is of benefit to us. Ensuring that the benefits are clear, well communicated and outweigh the costs and inconvenience is crucial if we are to be effective in advisory work.

Although in principle this seems straightforward many things conspire to ensure that we do not have it so easy. Not least of these is the disease itself for which it has been shown that whilst improvements in the incidence of disease can result from single straightforward interventions, it is “the result of the cumulative effects of many changes rather than the large influence of one or two factors” (8) that bring substantive and lasting improvement. The situation is complicated further as mastitis is a multifactorial disease the control of which requires a multi-faceted approach, and the most influential factors vary from farm to farm (8).

Although I am no expert in mastitis, I do have some direct experience of managing the condition from my early career and farm practice, and we shall return to the complex nature of the disease later. For now I shall look briefly at some wider contextual aspects to consider in determining how better to improve the application of technical knowledge to the management of the condition.

Why should we change what we do?

In farming, management activity is always either about preventing things changing for the worse or more hopefully focusing on how to improve things in the future. For dairy farmers that can be in terms of better individual cow and herd health, or improving yield and quality with the intention of improving profits. All of course in such ways that the costs of making changes outweigh the benefits achieved. Simple!

If it were that simple we would have had the problem sorted a long time ago. In exploring why we still are discussing this topic it is important to consider the context - which includes:

- the nature of the change or changes required,
- the nature of the business in which those changes have to occur,
- the personality of those involved in making the decision, and their aspirations and objectives,
- the external things that influence the way that personality sees the world and operates within it.

Mapping the nature of mastitis against these aspects, we can immediately see we are dealing with a disease that has complex management requirements sitting within a business environment that is in itself complex. It is also an environment that has had to face stiff challenges to remain viable against the complexities of price and policy changes. Furthermore all of this is influenced by individuals that are inherently complex in their aspirations, objectives and personalities. Consequently what, at first, may appear a simple solution to the problem of mastitis, emerging from research into the disease; has potentially, once it is applied in the field, to contend with a wide range of complex influences on is application or adoption.

Some research into farmers' information and decision making has suggested that farmers' innate decision making processes may not be particularly well equipped for making such complex decisions (5). Reasons for this may lie in the way that the priority to different aspects of the decision varies dependent depending upon the nature of the change or thing to be decided upon. Other experience suggests this may be because farmers differ psychologically in their approach to decision making (15). This work by ADAS and the Test Agency Limited found farmers were more anxiously inclined than the general working population. In relation to making changes to a farm system or practice it seems there is an issue about how farmers deal with risk.

Other factors also come in to play, for example, it has been found (13) that for all types of decision making economic issues occur in the first order of thinking. For simple tactical business decisions (day to day management decisions) such economic considerations were the most important influence on the decision outcome. This was also the case for decisions that have medium term horizons for their outcome and implementation.

However, for decisions that have longer term consequences, such as major strategic decisions that require significant changes in business strategy or investment, or have major personal or family consequences, other factors were of greater importance. This research showed in particular that legal or regulatory influences, personal preferences or aspirations, and the degree of impact on managerial time, involvement or skill were all of greater significance than the economic benefit alone.

A multifaceted disease requiring a multifactorial approach to its management and control clearly does not fit within the simple cost benefit approach taken with tactical decisions. Individual elements of control in regard to parlour routine or dry cow therapy may be considered primarily in regard to the marginal economic benefit of implementing them, and traditional approaches to influencing mastitis management through combinations of specific interventions, each of which in isolation can be shown to provide a benefit, have tended to focus on this approach. However, there is evidence that a whole farm approach is required for lasting benefits. Such a holistic approach is therefore inevitably one that requires changes throughout this complex system. These will be needed in terms of routines, overall day to day management, integrating the management of the herd, facilities and grassland, as well as frequently impacting on the management and investment in buildings and equipment. It is combination of tactical and strategic decisions.

This whole farm planning underlies the Herd Health Planning approach to disease prevention. But how these are used to bring about change may need further consideration. It has been found, 74% of dairy farmers have a Herd Health Plan (2) (this figure is even higher when only fully commercial herds are considered) although 63% of those dairy farmers who had a plan recorded that no improvement in herd health had been noticed. That is despite 50% of farmers having a plan prepared with the help of the farms veterinarian and many of these plans had been in place for a number of years. However, there is other evidence that reviewing mastitis records well and acting on the information did lead to improvements (7).

Clearly then this is a very complex set of circumstances and further work on this data is being undertaken by Defra at the time of writing. Bearing this in mind it is useful to consider some basic communication principles in relation to behaviour changes. Significant among these are:

- The need for information.
- The evaluation of that information.
- Will or motivation to change.
- Action.

I shall look at aspects of these in a little more depth.

Information needs

At the heart of decision making is the need for information. The inherent nature of the information, its source, means of delivery, relevance and accessibility all contribute to how it is perceived and used. Such considerations are important and need to be understood in evaluating information that a farmer is expected to act upon.

Is it accessible?
A lot of research has been done on the sources of information that farmers use. Consistent patterns emerge. For example an evaluation into Defra's Demonstration Farm Pilot Programme 'Forward Farming' (5) when those who had participated in the programme were asked about activities that might lead to a change in farming practices 92% mentioned the farming press, followed by 73% other farmers, 66% trade or manufacturers, then 60% the bank or accountant, 55% independent consultant. Interestingly for those who had not attended events the pattern was similar although percentages less. More recently interim findings from other work carried out for Defra - and still on-going - looking at behaviour change in farmers, found a similar range of sources but noted the wide variation in level of use (10). However, even where good sources of advice are available it does not mean it will bring about change as the ADAS Farmers Voice 2006 data showed.

Individual information-seeking behaviour may also vary consistently. For example, the Evaluation of the Demonstration Farm pilot found that there were differences in information seeking behaviour between those who attended events and those that did not. Potentially therefore there is a danger of preaching to the converted if the same approaches are always used for particular audiences. There is then no panacea for providing information to farmers.

A mix of routes has to be used and in that mix the advice and opinions of family members and other farmers features very significantly. Also these studies found that the supply of information is not necessarily the issue, indeed there is both a danger of confusion between different initiatives and congestion in terms of there being too much information.

Is it in a form that can be readily understood?
As the pressure on farming has increased, requiring increased productivity, in part achieved through the use of technology and the shedding of labour, and more recently the demands placed on farmers through regulatory requirements, the time available for information gathering and assimilation has diminished. Both in terms of engaging with informal networks such as through the livestock mart, or more formally through attending study days or demonstrations.

The sheer volume of information landing on farmers doorsteps has also increased. Both in the current Defra study (10) and an earlier study into the impact or farm regulation (1) this issue has been identified. Indeed in this latter study one case study interviewee reported he had received over 500 pages of information relating to the Single Farm Payment and CAP reform alone!

As a consequence any technical information has to be carefully drafted and presented if it is to find its way through this welter of material. Adopting a marketing approach to presentation and delivery may, in part, be one way of tackling this (11), where clear simple messages focusing on benefits are delivered regularly and tailored to be relevant to specific target groups.

Is it credible and believable?
Many farmers are unlikely to have the knowledge, skill or even inclination to evaluate the scientific detail that lies behind a specific piece of work. However they certainly will have a view on the individual and organisation that is promulgating it. Some research carried out for Defra (11) concluded that “Credibility, reliability, trust and affordability are important factors to farmers who use advisers.” It is these perceptions in regard to their integrity and believability that will make the difference between whether such information is properly considered in relation to their own business, or is dismissed without proper consideration.

Among the criteria used to evaluate the messenger are, familiarity and expertise in relation to their own farming system, common sense, and the ability to relate and interpret technical and scientific research into their own farm system. It is interesting that it was just these features that farmers identified in relation to officials who inspect and provide regulatory advice (1).

The emphasis placed by farmers on the views of their peers, needs to be taken into account. Work carried out by the Milk Development Council (MDC) (14), found that it is crucial that those farmers used as case studies or speaking on platforms are perceived as being similar enough to a target group’s own situation to have real relevance. They can provide real hard data that is seen as more believable than that obtained from research herds.

Is it relevant and compatible?
It is well understood that for information to be absorbed and acted upon it has to be relevant to the circumstances of the recipient. This is one reason that other farmers feature highly in farmers’ sources of information. Demonstrations held on research establishments, supply company or highly innovative farms are often not perceived as relevant as the circumstances are so very different from many of those of the recipients (6).

Working in an environment where so much is beyond their control because of biology, weather or regulation, farmers are inherently risk adverse. It is no surprise therefore that where they do have control they wish to minimise the risk of any intervention.

Even though information may be seen as relevant, there is still no guarantee it will be taken up. Farmers need to be convinced that the innovation fits comfortably with the procedures, processes and ways of working already present, hopefully without significant disruption. Most people are by nature creatures of habit, so if routines have to alter significantly there is a higher degree of risk that things will not happen or will be so modified that expected outcomes may be compromised. Or where the changes required are so major, for example altering cow bed sizes, changes may need to be delayed until resources are available or other major reorganisations are carried out. An example of this is where over half of farmers know they should not cross subsidise the farm from the Farm Single Payment, but over two thirds feel they have no alternative (3).

Evaluating information

Does it fit with inherent knowledge and skill?
The inherent knowledge an individual has of what works in their own situation is a crucial component in changing behaviour. Knowledge transfer is just that - exchanging knowledge; yet changing practice through changed behaviour requires a learning process. As a consequence approaches that facilitate learning, inspire confidence and build motivation to change are highly valued (12). This is particularly likely to be so where major changes in strategy are being considered and where new skills are required in order to put a desired strategy into effect.

Similarly if new technical and practical skills are needed the implementation of new practices cannot be effective until those skills are either learned on the job or imparted by others.

Does it fit with personal aspirations?
It is easy to assume that anyone running a business is out to optimise profit and for many that is indeed the case. But for others if achieving profit optimisation interferes with other aspirations, for example time available for family or another interest, then a lesser emphasis on financial reward may be acceptable to them. Consequently if the changes being proposed interfere with important other personal objectives, they are unlikely to be easily adopted. There is evidence that for most (80%) farmers profit is a prime motivator but for nearly 20% this is not the case (3), but enjoyment of farming is equally strong (82%) and agreed that "beyond earning a reasonable income, the main joy of farming is the lifestyle". However this varies with age and farm size.

So in considering how messages are framed and despite financial reward being important, it is clear other aspects of what it means to run a business need to be taken into account when communicating the complex messages of mastitis control.

From the fields of psychology we are aware that turning intentions into changes in behaviour is key and it is our beliefs, values and aspirations linked to those that are significant (16).

WHAT CAN WE DO BETTER TO HELP

In developing our communication strategies for effecting changes in approach to mastitis control, effort will be needed to develop an increasing understanding of the different segments of the dairy sector. Studies such as those mentioned here and others all have a part to play, but for those working with farmers' day-to-day, building up that knowledge locally is essential. In this way a finer grained approach can be taken to targeting appropriate solutions to specific groups.

Simple tools are useful, such as Force-field analysis. This is a technique for critically setting out to understand what may exist within the context for change. It forces one to identify that which will help to motivate the desired direction and what may actively be working against it. It still surprises me how many advisers and consultants have not systematically worked through these issues. In so doing we can perhaps identify others who can help.

I recall, when I was directly advising dairy farmers, when the payment based on the levels of Somatic Cell Count was introduced. The penalties were so stark that improvements over and above that achieved through advice alone happened almost over night. We are more sophisticated about such things now and relations with the dairy industry are on a different footing, so a better balance between threat and incentive may be more appropriate.

In preparing for this presentation I looked at the Dairy Farm Assurance standards and an approach adopted by Ben and Jerry's Homemade Inc. makers of Ice Cream in the USA and worldwide (9). My purpose is not to set one against the other but to try and see what differences there may be. I have no direct experience of either approach in practice. However, fundamental to the Ben and Jerry process is the mission zeal the company deploys to emphasise the interdependent nature of their suppliers, their own success and more widely the community and environment.

The approach here goes far wider than that incorporated within Farm Assurance encompassing the whole breath of sustainability. Interestingly it is also set up as a series of self completion educational modules each with a series of questions and scores, the aim being to inform as well as measure. Clearly underlying their methodology is a set of desirable standards and behaviours; however their learning based stance which challenges the farmer to assess how close they are to the desired outcome and providing information about how to achieve them is appealing.

It is also noticeable that the approach is based on a collaborative partnership between the farmers, Ben and Jerry's, farm suppliers, processors, university extension staff and dairy product manufacturers, that they now operate in Europe as well as in the States. Essential to their method is that it is driven by a set of fundamental values, for example:

"We support sustainable and safe methods of food production that reduce environmental degradation, maintain the productivity of the land over time, and support the economic viability of family farms and rural communities.

We believe in using the power of our day-to-day business decisions to help drive social change" (17).

The desire then with technical support is to get suppliers to align themselves with those values and apply the good practice identified, helped by farm veterinarians and other advisers. There then becomes a direct link between incentive and reward in regard to a highly focused and targeted supplier base, which is founded on the need to align behaviours to those that reflect the values, beliefs and standards of the company.

It would make an interesting study to look further at how holistic standards based self educational methodology would work in the UK. Perhaps to see if our current approaches can be adapted to create flexibility, with encouragement through a learning approach, whilst still retaining the absolute standards to retain retailer and customer confidence.

CONCLUSIONS

Why is so much advice left over from last year? I hope that what has been covered in this paper has shed some light on the complexity of the process which I believe is at the heart of the problem. Getting all aspects of the technical solutions to line up with, the wide variety of farmer aspirations, approaches to business and the complexity of the decision making process is a tall order. Although levels of disease remain stubbornly high, if we believe the technical and management solutions exist we have to look to the sciences of behaviour and communication for insight.

- Is our approach accessible to our target groups?
- Do we communicate in a form that can be readily understood?
- How can we ensure that we are seen as credible and believable?
- Are we sure what we are communicating is relevant and compatible with the farmers we try to influence?
- Does what we communicate fit with our understanding of the inherent knowledge and skill of our audience?
- How can we ensure that we tailor this closely with farmers' personal aspirations?

In understanding our audience better we will go some way to recognising the essence of this quote from Balaam (alias Thomas Pitt, 1653-1726):

"You should never take advice from any man, however well he knows his subject, unless he also knows you."

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THE MDC PLAN – A WAY FORWARD FOR UK MASTITIS CONTROL?

A J Bradley[1,2], K A Leach[1], J E Breen[1,3], L E Green[4] and M J Green[3,5]
[1] School of Clinical Veterinary Science, Division of Farm Animal Science, University of Bristol, Langford, Bristol, BS40 5DU, UK.
[2] Quality Milk Management Services Ltd, Unit 1, Lodge Hill Industrial Park, Westbury-sub-Mendip, Nr Wells, Somerset, BA5 1EY, UK.
[3] Orchard Veterinary Group, Wirrall Park, Glastonbury, Somerset, BA6 9XE, UK.
[4] Ecology and Epidemiology Group, Department of Biological Sciences, University of Warwick, Coventry, CV4 7AL, UK.
[5] School of Veterinary Medicine and Science and Department of Mathematical Sciences, The University of Nottingham, Sutton Bonington Campus, Sutton Bonington, LE12 5RD, UK.

SUMMARY

Bovine mastitis remains as a significant cause of financial loss to the UK dairy industry and there is little evidence that the situation has improved in recent years. This paper is designed to 'update' the reader on the most recent findings of the Mastitis Diagnosis and Control Plan (The MDC Plan) first outlined in the 2005 conference. In addition it details a pilot project currently being undertaken to assess the best route for 'roll out' of the Plan.

INTRODUCTION

Mastitis in UK dairy herds remains a major problem with clinical episodes alone considered to cost the industry in excess of 160 million pounds each year (2). Further losses are caused by sub-clinical infections through loss of milk yield and a potential reduction in milk price if bonuses are lost. Mastitis has further ramifications namely an important impact on cattle welfare and potential influences on public health (2) and the environment.

Despite the clear importance of bovine mastitis and an abundance of peer-reviewed literature on the subject, it is hard to be convinced that the UK has made any significant progress in preventing the disease for the last 15-20 years. The incidence rate of clinical mastitis is difficult to determine precisely but the most recent estimate, based on a prospective survey, places the figure at over 50 cases per 100 cows per annum (4) which is in excess of other estimates (1, 6, 3) and the last prospective survey in the 1980's (7). We have also seen a dramatic shift in the aetiology of bovine mastitis over the past 30 years with a clear shift away from the classical 'contagious' towards 'environmental' mastitis pathogens (2). One 'much heralded' success has been the decrease in bulk milk somatic cell counts (SCC) since the implementation of financial penalties in 1991; whilst this reduction has been coupled with a decrease in the incidence of contagious mastitis, unfortunately there is little evidence it is reflected in a reduction in new infection rates on farm and on the contrary there is significant evidence that infection rates have increased. Thus the bulk milk SCC reduction may simply have been through increased culling of high cell count cows.

The paper below briefly outlines the salient points of the development of the MDC Plan and details the outcomes of the intervention study that were used to demonstrate the efficacy of its application - a more detailed description and analysis has been published elsewhere (5). The approach to further validation of the Plan and subsequent national 'roll out' is also discussed.

DEVELOPMENT AND INITIAL TESTING OF THE MDC PLAN

The principle of the MDC Plan is that it should be possible, by gaining a better insight and understanding of the mastitis epidemiology on an individual dairy unit, to target mastitis control measures more specifically and thereby assure more cost effective mastitis control. Following development of the Plan an intervention study was developed to test the hypothesis that this well specified plan would result in a reduction in disease incidence in herds with an above average incidence of clinical mastitis; through the intervention study it was also hoped that we would be able to gain a better understanding of the importance of individual control measures – this aspect of the research is still ongoing.

Implementing the Plan – Making a Diagnosis.

A central precept of the plan is the requirement to 'diagnose' and define the mastitis patterns on a particular unit. Using this approach it is then possible, through the analysis of data and strategic bacteriology, to categorise farms according to whether the mastitis on the farm is of dry period or lactation origin, whether the pathogens are behaving in an 'environmental' or 'contagious' type manner as well as defining seasonal variations in aetiology. Once farms have been categorised in this manner it is then possible to 'target' interventions to achieve the biggest return on mastitis control investments. Examples of the approach to diagnosis will be provided at the conference.

The Intervention Study

An intervention study was conducted in 2004/5 to validate and test the MDC Plan as well as to investigate on farm factors important in mastitis control. The salient points of this study are outlined below:

- The MDC Plan was developed using current literature as its basis. The plan contained over 300 points (encapsulating best practice) but the concept is that the 'diagnosis' allows the user to target a small number (10-20) points in the Plan to achieve improved mastitis and milk quality control. To this end the Plan is divided into sections (mirroring cow management and the lactation cycle) and within each section different aspects are categorised as things the farmer 'could', 'should' or 'must' be doing – the exact weighting of these points then varies according to the 'diagnosis'. The approach is outlined below:

1. Define the herd situation using appropriate clinical mastitis and cell count indices.
2. Use strategic bacteriological samples to confirm pathogens
3. Assess current herd control measures against the Plan 'gold standard'.
4. Define areas of control that need to be addressed but prioritise them according to the patterns of mastitis identified on the unit.
5. Confer with the farmer every four months to re-appraise the data and re-assess the targeted control plan.

- 52 herds were selected at random from herds that undertook milk recording with NMR and that had an incidence rate of clinical mastitis above the national average (taken to be 35 cases per 100 cows per year)

- The average herd size in the study was around 150 cows and the average incidence of clinical mastitis before the study commenced was approximately 85 quarter cases per 100 cows per year.

- Herds were split into two groups of 26 (intervention and control) and matched on bulk milk cell counts and geographical location.

- The mastitis control plan was carried out on the 26 intervention farms but not on the 26 controls. All farms were closely monitored throughout the study period.

- During and at the end of the study, prior to analysis, each farm was categorised according to the degree of compliance with respect to the Plan. Herds were group according to compliance as outlined below:

  - Group 1: <33% of recommendations implemented
  - Group 2: >33% but <66% of recommendations implemented
  - Group 3: >66% of recommendations implemented

- The change in incidence of clinical and sub-clinical mastitis over a 24 month period was assessed between intervention and control farms, using the parameters outlined below:

  - IRCA: Incidence rate of cows affected with clinical mastitis (within a lactation cycle).
  - IRCM: Incidence rate of clinical mastitis (within a lactation cycle).
  - SCCNI: Proportion of cows calving in with an elevated somatic cell count.

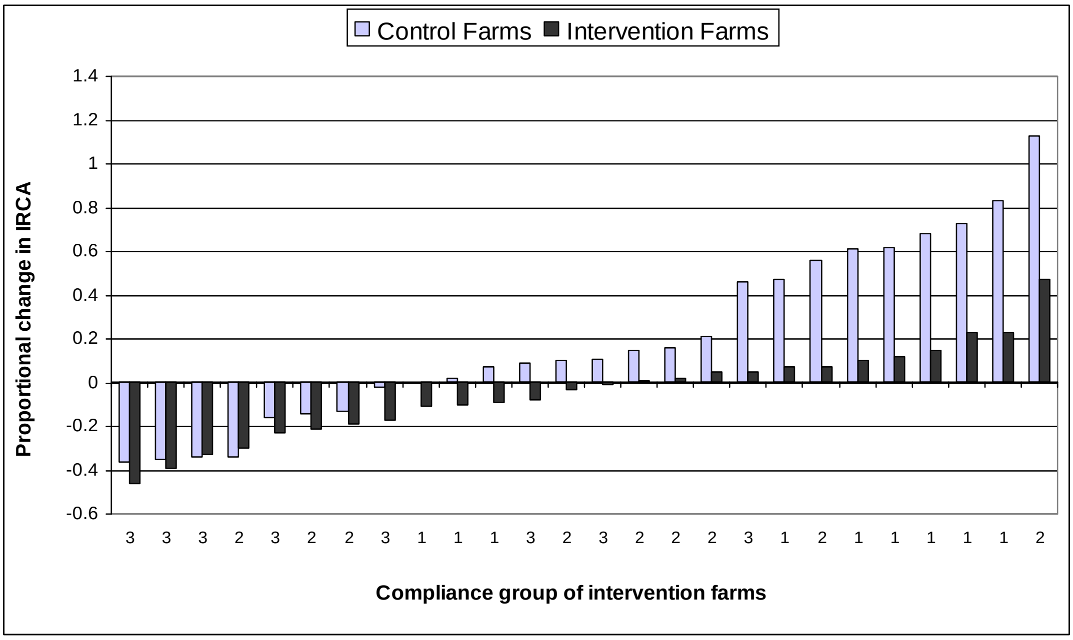
- Main causal factors that influenced the success of the control strategy were investigated.

The Impact of the Plan

The impact of the Plan was assessed using both univariable and multivariable analyses, the key findings of which are outlined below. A more in depth analysis has been published elsewhere (5).

As one would expect the rates of mastitis changed in both intervention and control herds, with herds in both categories experiencing increases and decreases in mastitis – this change is illustrated for all farms in Figure 1. However, when considered overall, more intervention farms experienced a decrease in mastitis incidence than control farms, and those intervention farms which experienced an increase, experienced a smaller increase (on average) than control farms. This is not unexpected as there are likely to be significant year on year variations and although the control farms did not receive the Plan they were not precluded from seeking mastitis advice elsewhere.

Figure 1 Individual farm results for the proportional change in IRCA after implementation of the mastitis control intervention (after Green *et al* 2007).



When the degree of compliance was considered in the analysis it became clear that the level of compliance was a significant factor in determining the likely benefit of the plan. The impact of compliance on the median changes in the rates of the measured indices is outlined in Table 1. Significant improvements were only achieved by herds in compliance groups 2 and 3. Only the highest compliance group (Group 3) experienced significant reductions in all the measured indices.

Table 1 Proportional changes in IRCA, IRCM and SCCNI after the mastitis control intervention was carried out (after Green *et al.* 2007).

	Control Farms	All Intervention Farms	Compliance Group 1	Compliance Group 2	Compliance Group 3
n	26	26	9	9	8
Median Change in IRCA	0.11	-0.02	0.10	0.01	-0.20
Median Change in IRCM	0.09	-0.05	0.08	-0.03	-0.18
Median Change in SCCNI	0.12	-0.08	-0.03	-0.14	-0.22

The MDC Plan – A way forward? – Issues and Challenges.

Our findings from this research suggest that there is significant scope to improve the mastitis situation in the UK through the application of current knowledge. The challenge that now remains is how best to convey and implement that knowledge on a national scale. To that end the Milk Development Council commissioned a further pilot study to investigate ways of 'rolling out' the plan. This study is still ongoing as this paper is being written – an update will be given at the conference.

Whatever the outcome of the pilot study the difficult question will remain as to 'whose responsibility is it and can we find a better model for mastitis prevention in the UK?'. Implementing a national mastitis control plan that works would benefit the producer (financial), the milk purchaser (milk quality, residues), the veterinary surgeon (more fee paying time less reliance on medicines), the 'dairy industry' (better image for milk quality and welfare), the consumer (happy with reduced disease in farmed animals), and the politicians (lower endemic disease, better welfare, better structure for farm vets to work in). Given that the MDC Plan has been demonstrated to work – How do we make it happen?

THE PILOT STUDY

Background

Following the successful implementation of the MDC Plan in a research context, the decision was taken to trial its implementation via a third party (*i.e.* implementation was not carried out by the original authors of the plan) in order to identify potential issues associated with the 'roll out' and 'generalisation' of the MDC Plan.

Approach

In the summer of 2006 a number of farmers were approached to participate in the study. Once accepted they were asked to approach their veterinary surgeons to request their participation. Twenty two farms initially agreed to participate encompassing nineteen veterinary surgeons.

The veterinary surgeons were invited to attend two days training in the autumn of 2006, an initial day to receive training in the approach to diagnosis and implementation of the plan and a subsequent day to discuss individual issues. Following this, and as an integral part of the training, the veterinary surgeons were facilitated in implementation of the plan on farm. This facilitation comprised support in data analysis and interpretation, but did not include specific advice with respect to plan implementation on farm as the purpose of this pilot study is to better understand the issues involved in the implementation of the plan by third parties.

As this paper is being written the final stages of implementation are being undertaken, with a view to collating and analysing data to assess the impact of the plan this autumn. Following final collation of the data the twenty two intervention farms will be compared to a similar cohort of controls and the efficacy of the plan, when implemented by third parties, assessed.

THE FUTURE

The strategy for national ‘roll out’ of the MDC Plan is currently being developed and will be refined later this year in the light of the findings of the Pilot Study.

CONCLUSIONS

The MDC Plan offers a potential route and opportunity for improved mastitis control in the UK. Its effective implementation will require the cooperation of all members of the industry from farmers and herdspersons through consultants and veterinary surgeons to recording organisations. Whilst the plan has been demonstrated to work on farms where it is wholeheartedly implemented the real challenge lies in persuading the not insignificant minority of the industry who lack the ‘motivation’ (be that financial or otherwise) to engage in the process.

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ACUTE PHASE PROTEINS TO IDENTIFY INFECTION

Paul Torgerson
Tri Delta, Switzerland

No written paper has been submitted.

THE IMPACT OF HOUSING ON MASTITIS

Diana Allen
QNM Ltd, 46A Mudford Road, Yeovil, Somerset, BA21 4AB. Email: Diana@qnm.ltd.uk

SUMMARY

Good cow comfort has a major effect on reducing stress in the modern high yielding dairy cow that is likely to be housed for most of the year. Adequate fresh air, light, space and a comfortable bed are key components of good cow comfort. This paper looks at why cow comfort is so important and how to achieve it.

INTRODUCTION

Cow comfort, health and nutrition are highly inter-related and are the subject of a Nuffield Scholarship which I have recently completed (1). The key to consistently controlling mastitis and somatic cell count in dairy herds lies in implementing good parlour and cow management routines and maintaining strong immune systems by minimising stress in dairy cows.

Why is cow comfort so important?

Cows need fresh air, light, space and a comfortable bed to lie in. Recent research from Denmark (3) has shown that cows show considerable signs of stress with less than 10 hours lying time and the optimum appears to be over 12 hours. When lying and eating are restricted simultaneously, cows prefer to lie down rather than eat (4). In overstocked buildings cows spent more time standing in the dung passage waiting for a free cubicle than eating. If cows are not lying down for sufficient time during a day they will be standing on slurry contaminated concrete. This increases the likelihood of dirty legs and udders and foot problems such as digital dermatitis, foot rot and sole ulcers.

Adequate rest is essential for a healthy immune system. Cows ruminate more while lying down than standing up and rumination is essential for providing saliva, rumen buffering and efficient microbial fermentation and rumen health. Rumination also provides the physiological rest and rejuvenation ordinarily provided by deep sleep. If milking takes 2.5 hours and all the cows are shut in the collecting yard, then the cows at the back of the pack could be away from feed and cubicles for 5 hours or more a day. This will have an impact on the amount of time they lie down and rest.

New technology is available which will help us get a better idea of lying times. Ice Robotics (based in Edinburgh) have a sophisticated pedometer that measures time spent standing, time spent lying as well as number of steps. Researchers in Denmark are currently validating this technology on commercial farms and I hope to do some similar work on farms in the UK using the IceTags. Other exciting new technology that is being trialled in Denmark is the Bluetooth technology to give real time movement knowledge on cows in the herd. This is relatively cheap technology and with a few receptors in the barn it should be possible to know how many hours a day each cow has been eating, lying down, standing and walking. This will make possible the early detection of health problems and allow more accurate heat detection.

What is required for good cow comfort?

Fresh air

Cow housing used to be built for warmth and convenience for the farmer. Low roofs and poor air flow, as shown by excessive condensation and plenty of cobwebs, are bad for cows. Many of the cow buildings seen on my Nuffield Scholarship travels have been very open and the winter climates are far harsher than the UK climate. Cows do not need protecting from the cold but they do need good ventilation, especially if summer housing is a consideration. Protection from driving rain is essential but this can be achieved with overhanging roofs or by designing the building to have head to head cubicles with passageways on the outer wall rather than cubicles. This allows for open sided buildings.

Options for improving ventilation:

- Open sides or sidewall curtains which can be manually or automatically raised or lowered.
- Knock out every other space board on the sheltered side of a building.
- Leave roof ridges open over a central feed passage.
- Slot existing roof sheets.
- Spaced roofing sheets i.e. sheets laid upside down with 15-25mm (0.6–1”) gap between each.
- Remove blocks, wood or tin from under the eaves to create more air inlets.
- Install fans to increase the air flow.

Light

Dark, dingy buildings are no good for cows or for stockmen trying to spot bulling cows. Cows do better in bright, airy buildings. There is considerable trial evidence from several countries showing an 8 to 16% milk yield increase when increased day length lighting is adopted. The lights need to be on a timer so that there are 18 hours of light at 200 lux (sufficient to be able to read a newspaper at cow height) and 6 hours dark (maximum background lighting 20 lux) when all cows should be lying down if there is sufficient space and cubicles.

Space

Cows need space to show bulling behaviour. Heifers and subordinate cows need space to get away from more dominant cows. Even where space is theoretically adequate, if cows don't stand or lie in the cubicles and get away from standing in slurry, foot health and cleanliness will suffer. The degree of leg contamination in cattle buildings depends on the design of the building, the frequency of scraping, stocking density and cubicle comfort and lying times.

The ideal situation is to have wide dung passages and a wide feed passage as well as a loafing area outside, preferably with a bull pen in the corner. The difference between a 3 row shed (3 rows of cubicles to one feed trough) which typically allows 6.5m^2 per cow and a 2 row shed (2 rows of cubicles to one feed trough), typically 7.5m^2/cow is the amount of slurry the cows have to walk through (25% less loafing area) and the pressure at the feed face. There is a cost difference in the building (15% more/cow for a 2 row shed) but it is relatively small and over the long term this cost is negated by less stress on the animals. The extra management and stockmanship required to get the best out of a three row system is substantial. Feed has to be pushed up more often, slurry has to be scraped out more frequently and any overstocking will have an adverse effect on cow production as well as udder and general health.

Cubicle Sheds

- Minimum width of scrape passage 3.6m.
- Minimum width of feed passage 4.26m.
- Minimum width of feed passage if cows back out of cubicles into passage 5m.
- Install cross passages every 20 cows.
- Minimum width of cross passage without water trough 2.4m.
- Minimum width of cross passage with water trough 3.6m.

Straw Yards

- Rectangular yards are best with access to feed along the whole length of the yard.
- Bedded area 7m^2/cow minimum.
- Scraped feeding/loafing area 3m^2 minimum.
- Minimum width of the feed/loafing passage 4m.

Cows are more likely to be overstocked in North America than in the UK since we have welfare regulations that state that there should be more cubicles available than the number of cows in a group. In North America it is quite common to see units that are running at 120 – 130% overstocked. At this level, standing time is increased by 15 to 25%, rumination may be reduced by as much as 25% and resting time is reduced by 12 to 27%.

Overstocking greatly increases the risk of displaced abomasums, dirtier cows and more mastitis.

Water Troughs

Milk is 87% water and cows need a lot of clean, good quality water to produce high yields of milk. Bore hole water should be tested regularly for bacterial and mineral content. Cows have a good sense of smell and contaminated water leads to reduced consumption. Drinking water with a high bacterial load will compromise the immune system and increase mastitis incidence. One of my clients has reduced his clinical mastitis cases from 30 per month down to 6 by adding hypochlorite to the header tanks which feed the water troughs.

Feed Troughs

Cows are social animals and they have a social hierarchy. Swedish research has shown that when feed space is short but feed was not limited, cows had shorter average eating times and accelerated eating rates but feed intake was unchanged. In contrast, when feed was limited, dominant cows consumed 14% more feed than submissive cows. When both feed and feed space was limited dominant cows ate 23% more feed than the submissive cows. Submissive cows also altered their feeding behaviour, eating much more during the night. As trough space is reduced there is a greater risk of metabolic problems such as acidosis and displaced abomasums because of the faster eating rate.

Feeding step

A small step for the front feet keeps them out of the way of the automatic scrapers. This works well with perimeter feeding where the step encompasses the stanchions making scraping behind the step easy. The step should be 0.5–0.6m wide and 0.1m high

Swedish Feed Stalls

Although these are expensive compared to other feed barriers they do ensure that cows are not standing in slurry while they are eating. The concrete platform is usually 1.6m wide and 0.2–0.3m high. Mini cubicle divisions set at 0.8m stop cows walking along the platform and keep it free from dung. Ideally the platform is covered with rubber matting.

Flooring

All flooring should be non slip and free from pot holes to prevent cow injuries and hoof damage. For cows that are housed all year round I think that the cost of rubber flooring is justified. Good quality research results in the UK are minimal but there is a lot of farmer experience in Canada and USA and some good research work from Sweden. Work in Florida has shown a 1.5 year payback on installing rubber mats due to reduced treatments for lameness.

My conclusions on rubber flooring so far are as follows:

- Do not lay rubber in any passageways if the cubicles are small and uncomfortable, since cows will choose to lay on the rubber in preference.
- Priority areas for laying rubber are (1) parlour, (2) collecting yard and (3) feed passage.
- Laying rubber in the parlour and at the parlour end of the collecting yard can really help to encourage cows into the parlour.
- Laying rubber down the feed passage is more important in herds milked 3 times a day because cow behaviour is more synchronised.
- When laying new concrete in buildings, consider insetting rubber in strips for the front feet and back feet down the feed passage to reduce the capital cost.
- Second hand rubber quarry belting bolted down by the feed face is a cheap alternative but you need to check the rubber before buying to make sure it is not too worn.

Cubicle design

The critical areas for cubicle comfort are:

- Sufficient total length to allow the cow to lunge forward unrestricted when getting up.
  - 2.6m for cubicles by a wall (minimum);
  - 2.4m open fronted cubicles (minimum).
- Sufficient bed length so that a cow can stand with all 4 feet on the cubicle and can lie down with all her udder comfortably in the cubicle.
  - 1.7 – 1.8m from brisket board to back of cubicle (or inside of concrete kerb for sand bedded cubicles).
- Maximum height of brisket locator of 0.1m so that she can step over it when lunging forward. Poly pillows, metal or toughened plastic pipes or wooden boards (angled away from cow with smooth edges) work well.
  - 12cm gap between brisket locator and bottom rail to prevent trapped feet;
  - Concrete fillets are expensive and prevent front leg extension on rising.
- Sufficient width so that she can comfortably lie on her side without being obstructed by the next cow.
  - 1.22m between divisions where there is a solid support leg;
  - 1.17m for suspended cantilever divisions;
  - 1.07m for first lactation heifers;
  - 1.27m for heavily pregnant dry cows.
- Sufficient neck rail height and correct placement to encourage her to stand in the cubicle and not half in half out.
  - 1.22–1.27m above base of cubicle;
  - 1.7–1.8m from back of cubicle usually directly over the brisket board;

  - 2.1m diagonal distance from head rail to edge of kerb.
- Prevent cows from being trapped under the lower cubicle division.
  - For simple U loops 0.3–0.45m between lower rail and surface of bed;
  - For designs where lower rail bends up, the turn should be less than 30cm from the brisket board to allow resting positions under the partition or more than 76cm to prevent diagonal lying.
- Where lunging space is limited and cows have to lunge sideways use a wide loop and low mount that does not inhibit the ability to lunge over it.
  - Lower rail <30cm from top of mattress;
  - Upper rail – neck rail height i.e. 122–127cm.
- Where deterrent straps are needed on head to head cubicles to stop groups being mixed up it should be fixed high enough not to interfere with lunging.
  - Deterrent bar/strap 102cm above bed height.
- Kerb height of 0.15–0.2m.
- Kerbs for sand cubicles should be designed to keep sand in, are usually 10–15cm wide and should slope inwards so that as sand level drops the cow is not lying against a sharp edge.
- 2–3% slope from front to back for mattress cubicles.
- 1–2% slope (or level) for sand cubicles.

Cubicle base

There are a huge range of mattresses and mats on the market. The older style EVA rubber mats stretch and harden over time as does the rubber crumb in mattresses. However, the newer rubber mats often have a foam layer underneath the rubber which increases the softness considerably and the longevity looks good. Some manufactures of good quality mattresses guarantee them for 10 years. The new dual chamber water beds are a big improvement on the single chamber beds and give good cow comfort. However, it is a mistake to think that any of these 'soft beds' need only a sprinkling of bedding to absorb any moisture. They all need several centimetres of bedding on top of the surface in order to avoid friction rubbings of the hocks and to help ensure that cows lay clean. This is obviously a major factor in mastitis control.

Cubicle bedding

A decent amount of bedding can make small cubicles more comfortable. The biggest mistake I see is when farmers install rubber mats or mattresses and then expect that a thin dusting of sawdust will be sufficient. Bacteria need warmth, moisture and a food source to survive. Moisture is the easiest to eliminate by using adequate bedding, together with correct ventilation. No matter what type of bedding is used, all cubicles should be checked twice a day and any soiled bedding removed.

Sand

Sand is known as the gold standard of bedding material but only if maintained well. It is inert and therefore does not encourage bacterial growth. It is cool in summer and gives the perfect cushion effect for the cow. Fresh sand should be added at least once a week and the beds raked level every day. The type of sand is also important. Fine sand with clay in it can turn to concrete when wet and is no good. Test the quality of the sand by picking up a handful, making a ball and passing it from hand to hand. Good quality sand should break apart from the ball and not stay clumped together.

Recent research at UBC (2) has shown the effect of maintenance of sand bedded stalls on lying time. Any loss of sand or an uneven sand profile resulted in reduced lying time per 24 hours. The average length of lying bouts was also reduced. Based on this data it is estimated that for each one cm of sand lost below the kerb, lying time was decreased by 11 minutes per 24 hour period.

Research from the University of Wisconsin has shown little difference in lying times between mattresses with sawdust and sand when cows are not lame but once cows are lame they prefer the sand cubicles. The researchers suggest that lame cows struggle to get up and down on mattresses whereas on sand the traction and give is better and results in less pain for the lame cow.

Sawdust

Some sources of sawdust can be very abrasive and can cause hock lesions. Kiln-dried sawdust has the advantage that the drying process should have killed off most bacteria. The sawdust must be stored in the dry otherwise it can quickly heat up and become a breeding ground for bacteria. Cubicles will need a minimum of 3kg/head/day.

Straw

Both long and chopped straw can be good sources of bedding for cubicles as long as it is kept clean and dry and topped up regularly. Straw yards need to be bedded up daily with 18 kg/head/day and cleaned out completely every 3 to 4 weeks. Cubicles will use a minimum of 5kg/head/day.

Dry cow housing

A cow is most susceptible to mastitis during the 2 weeks after drying off and the 2 weeks before and after calving. In herds experiencing environmental *Streptococci* mastitis problems, especially in early lactation, the dry cow housing should be evaluated. *Streptococci* flourish on straw and when combined with poorly ventilated dry cow sheds the result is very high levels of bacterial contamination.

CONCLUSIONS

Good cow comfort is one of the key areas that farmers can control to reduce stress on dairy cows and thereby minimise the risks of mastitis. By ensuring that buildings are designed (or modified) to provide a comfortable and clean environment for cows, the bacterial challenge should be reduced and the cow's immune system should be less compromised. Without clean, dry and comfortable housing the opportunities for good levels of mastitis control will be limited.

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THE IMPACT OF HEAT STRESS ON MASTITIS

Brian R Pocknee
ADAS UK Ltd, Ceres House, 2 Searby Road, Lincoln, LN2 4DW, UK.
brian.pocknee@adas.co.uk

SUMMARY

Increasing global temperatures and more intense weather patterns, whatever the specific cause, is certain to occur within our lifetimes. Not only will this impinge directly on humans, it will also affect how we manage livestock. Heat stress affects all animals to one degree or another. Although in many parts of the world heat stress of dairy cows is readily acknowledged, and actions taken to mitigate the problem, it is not currently considered, by many, to be an issue in the UK. The only exception is during long hot summers and periods of drought. This is in fact an underestimate of the situation in the UK, with heat stress in housed conditions commonly occurring in the winter period. We have to realise that it is not purely a summer condition. The effects of heat stress are many and varied, with increased respiration and water consumption being noted by livestock keepers. Many would comment that infertility is impaired as are milk yields. However, one serious, but often ignored, adverse affect of heat stress is the increased incidence of both clinical and sub-clinical mastitis.

INTRODUCTION

Dairy cows are homeothermic animals and need to maintain a constant body temperature at around 38°C. Many factors affect body temperature, including air and radiant temperature, wind speed and relative humidity. High yielding cows fed appropriately are generally never cold as they can be compared to walking furnaces. For example, a 600 kg cow producing a modest 30 litres/day, generates around 1.4kW/hr of heat energy. This heat output will be even greater with today's high genetic merit dairy cows. Inevitably, this heat production increases the chances that she will be heat stressed at higher temperatures.

Dairy cows, like people, are their most productive when they are most comfortable and least stressed. In a British climate one factor we may not imagine to affect dairy cows is that of heat stress, but due to the increased production of today's modern day Holsteins, cows are 'working' harder to utilize the vast amounts of feed offered to them in supporting their needs. This 'work' involved in digestion creates more heat energy which needs to be removed from the body. This is harder to do in our 'muggy' British climate which may well lead to mild heat stress in dairy cows in average UK conditions, with high yielding cows being more at risk (9, 12, 16). All this before we consider the effects of global warming!

The immediate observed signs of heat stress in dairy cattle is that the respiration rate (panting) increases as does her water intake (5, 6, 12, 16). The prognosis can be confirmed by taking the rectal temperature of such animals, although of course there are many other causes of increased temperature. When heat stressed cattle change their eating behaviour, selectively eating wherever possible, feeds which are readily digestible and leaving the forage/roughage element. Cattle inherently appear to know that fermentation in the rumen of these feeds creates heat, causing them thermal discomfort. Besides selectively eating feeds, their total feed intake is reduced. Not only does this lead to a reduction in milk yield, the composition of milk changes with decreases likely in both butterfat and protein. The knock on effect of selective feeding may also be acidosis, due to the changing forage:concentrate ratios, and also the onset of ketotic cows – both can result in death.

Many dairy herds report a decline in fertility following periods of high temperature, either as a reduction in the number of observed heats (the heat period is shorter, there are less standing mounts and more silent heats) or cows not holding to service. The latter is commonly due to an increase in embryonic loss. The weight of the calf at birth is often also associated with heat stress in the critical times of the pregnancy. One problem of heat stress in dairy cows that is commonly overlooked is an increase in both clinical cases of mastitis and somatic cell counts (SCC). This is due to both the subsequent affects of heat stress on areas such as cow cleanliness, e.g. husbandry/management factors (7, 11), as well as more fundamental causes such as an impaired immune system (5, 17).

The actual reasons for the adverse affects of heat stress are many and varied but are often considered to be as the result of sub-optimal nutrient intake. This paper, however, will concentrate on issues relating to the impact of heat stress on the decrease in the cow's response to bacteria entering the udder, leading to increased risk of mastitis (2, 4, 5, 7, 12).

Heat Stress

Cattle exchange heat through convection, conduction, evaporation and radiation. They are not mutually compatible so we have scenarios where a cow standing in the sun on a cold day where heat is transferred by conduction, convection and radiation to the environment but the environment is transferring heat to the cow via radiation.

Dairy cows have a thermoneutral zone (or comfort zone) within which they work best (1, 5, 6, 12). At either end of this comfort zone are critical temperatures at which the cow becomes stressed and performance is reduced. Below the Lower Critical Temperature (LCT) (estimated at approximately -5°C) cows have to eat more just to stay warm and milk production drops. Above the Higher Critical Temperature (UCT) (around 25°C) cows attempt to lose heat by sweating, but because they sweat at only 10% of the human rate they are far more susceptible to heat stress. Both the LCT and the UCT are profoundly affected by a long list of variables including liveweight, breed, coat characteristics, feeding level and quality, level of production, wind speed, rain, radiative environment (sunshine) and relative humidity. Simple values can, therefore, be somewhat misleading.

Air temperature and radiant temperature directly influences the heat exchange ability of the animal. As wind speed increases, so does the amount of heat transfer from the surface of the cow. Increasing airflow over a cow has a dramatic effect on evaporative heat loss from the skin. Air flows as low as 10 km/hr (2.8 m/sec) can reduce respiration rates in heat stressed animals by as much as 50%.

When the relative humidity increases, the UCT will fall and animals will become heat stressed more quickly. Relative humidity can be a problem in either the summer or the winter. In winter, it can make the animals coats wet which reduces their insulating properties. In summer, it reduces evaporation and limits heat loss.

As the ambient temperature increases above the UCT, milk yields can fall by as much as 20%, with even greater drops being quoted (16). There is evidence that heat stress is most marked when it comes in short periods with no time for the cow to adapt to the rising temperatures.

The Temperature–Humidity index (THI) is an indicator used in the USA to assess heat stress. When the THI exceeds 72, the animal is considered to be heat stressed (Table 1).

Table 1 Temperature Humidity Index - THI

Temp °C	**RH %**										
	0	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
22									**72**	**72**	**72**
24						**72**	**72**	**72**	73	74	75
26				**72**	**72**	74	74	76	77	78	79
28			**72**	74	74	76	78	79	82	83	84
30		**72**	74	75	77	78	80	81	83	85	86
32	**72**	74	76	78	79	81	83	85	86	88	90
34	74	76	78	80	82	84	86	88	90	90	94
36	76	78	80	83	85	87	90	91	94	95	98

When the THI level of 72 is reached, the cow becomes stressed with temperatures as low as 22°C when the relative humidity is high (80-85%). As the humidity falls, the temperature at which the cow becomes stressed rises. When humidity is only 10%, the ambient temperature can be 29.4° C before the cow becomes stressed.

At THI's of between 72 and 79 the cow is deemed to be mildly stressed. When the THI is in the low to mid 80's the cow is considered to have medium stress, thereafter she is severely stressed. When the THI exceeds 100, animals will die. However, at all levels of heat stress the animal is suffering, there is a welfare issue besides the increased level of disease and metabolic problems, and her productivity and profitability suffers.

Although heat stress is often considered to be a summer problem, cows housed in the winter can readily become heat stressed, partly because of the reducing effect that humidity has on the UCT. In addition, the temperature of a fully stocked building can be up to 10°C higher than the outside ambient temperature. Therefore with a RH of around 55% depressing the UCT by around 8°C, i.e. to around 17°C and with the average temperature in the West Country during the winter being 8-10°C, it is quite feasible for many herds to be suffering mild heat stress as a consequence.

The THI is compounded by radiant heat loads (Table 2). If radiant heat loads are high, for example due to strong sunshine, the UCT could be as low as 20°C. Add to this the affect of humidity on the cow's well being and her behavioural response, then severe problems can be building up.

Table 2 Effect of strong sunshine on Upper Critical Temperature (UCT)

Solar Intensity (W/m² absorbed by coat)	Depression in UCT (îC)
0	0
100	1
300	2
500 (tropical)	3

(600kg dairy cow)

On a sunny afternoon the solar intensity has been measured as high as 900W/m² in Britain, but the cow's coat usually reflects much of this. Matters are not necessarily any better for housed animals. Uninsulated roofs allow substantial amounts of solar penetration - a solar intensity of 850W/m² has been measured coming through a collecting yard roof, which in effect reduces the UCT by around 5°C. At least with cows kept indoors they can normally move around and avoid such direct heat, e.g. go to the north side of the buidling, which is not the case with cows in collecting yards. Radiant heat therefore has obvious implications for both grazing and summer housed cows.

Matters are exacerbated with roof lights. Sunlight flows through roof lights and can cause a significant increase in ambient temperatures inside a building. There is a long standing recommendation that at least 10% of the roof area should be fitted as rooflights. Some sheds are being constructed with up to 20% rooflights. Although the environment within the shed is extremely light and pleasant at this level of natural lighting, it can create significant problems with the ingress of solar radiation. We therefore have a conflict between maximum amounts of natural light to ease photoperiod management and restricting roof light space to reduce temperatures in the summer months when cows are housed.

Heat Stress and Mastitis

It appears that 2 forces are in place with regards to an increase in mastitis as a result of heat stress. Firstly heat and humidity may increase the pathogen load in the environment (field or housing) (8), resulting in a greater incidence of mastitis in warm weather. In addition, evidence suggests that some of the seasonal changes in the levels of mastitis may result from a decrease in resistance of the cow's immune system, and the endocrine system (prolactin and cortisol) may be involved (5). Changes in immune function may be due to metabolic diseases, nutritional management, heat stress (8). Direct and indirect effects of heat stress on immune function and disease are being quantified (15). What is known is that cooling cows lead to a reduction in the level of mastitis (8).

Light and temperature both increase prolactin levels. There is a relationship between lower prepartum concentrations of prolactin and higher health and performance in the next lactation (5). In a teat sealant trial in Minnesota, differences in results were attributed to associations with heat stress which may compound the immunosupression that frequently occurs in periparturient cows (8), leading to a reduced ability to eliminate infection if a pathogen did invade the udder or due to increased shedding from infected glands.

Breed differences in tolerance to heat stress are also evident (14), with milk production and reproductive efficiency being less depressed in Jersey than Holstein cattle.

It is suggested that an increase in the level of SCC with temperature is not the result of the temperature *per se* but due to the increased exposure of teat ends to pathogens in hot weather (11) resulting in more new infections and clinical cases in the summer months (11). Others do suggest a link.

A review of studies on heat stress by workers at Kansas State University (2) indicated that most heat stress studies did not show an increase in SCC, and that the increase in SCC during the summer months is as result of an increased development of clinical mastitis, due to impairment of the mastitis defence mechanism or due to greater exposure to pathogens. The same review highlighted work by Elvinger *et al.* (1992) that indicated heat stress reduced the immune response of cows compared to controls and was attributed to a decreased migration of leucocytes to the udder observed in the heat stressed cows.

Finally, other factors may be associated with the increased level of mastitis in periods of high temperature, such as the risk of increased mastitis due to flies and the environment of the stockpersons. If the staff looking after the cows are working in uncomfortable conditions and are themselves heat stressed, then it is entirely probable that milking routines, housing and grazing management may be impaired.

Combating Heat Stress

In the USA where heat stress is a major problem in many states regular monitoring of respiratory rate is routinely carried out. If more than 7 out of 10 cows have a rate greater than 80 breaths per minute then they are probably showing signs of heat stress (16) and remedial action can be taken. Similarly if the rectal temperatures in 7 out of 10 cows are above 39.4°C then the animals are probably heat stressed. (16).

First step in minimising the risks of heat stress is the provision of cool, clean water and shade. With housed cows air movement is also essential. Water consumption can increase by as much as 50% (12) when the THI is above 80. Water should be close to shade - in high temperatures, humidity and sunshine cows will not walk more than 30m to access water (16).

Cows will positively seek out shelter (5). Shading from direct sunlight is imperative, but care must be taken not to create foul and damp underfoot areas as a result of cows always congregating in the area. A sure fire way of increasing the bacterial load on cows' teats and therefore clinical mastitis. Over time areas under trees can be so compacted and polluted that the trees die (16).

If UK summers become hotter with increased sunshine then the provision of portable and temporary shades will need to be considered. In the USA it is commonly recommended to provide at least $3m^2$ but preferably $5.5m^2$ per cow and set about 3.5m high. Portability may be very important to prevent foul and wet areas from forming. This can be minimised by positioning the shading on a north-south axis as this will allow around 50% of the covered area to be exposed to the sun and hence dry out. However, if cows are confined then an east-west orientation is better as this provides a greater percentage of shade cover than a north-south axis.

In herds where housing facilities are not ideal then more permanent shading areas may be necessary. It is, however, essential that the same design considerations are given to their construction as for main housing, e.g. air movement, air outlets, etc. Detailed examples of both temporary and permanent shade structures are provided by the various advisory/extension services provided by many USA states and universities (e.g. 1, 3, 12, 16).

Cooling cows while at pasture can be achieved by the provision of cooling ponds, as cows willingly immerse themselves in water. Surprisingly, there is no apparent adverse effect on the levels of mastitis when monitored in Florida (9, 12). In fact in a large (1400 cow) herd, groups with access to ponds as well as shading had half the incidence of mastitis and reduced SCC compared with groups with access to shade only. Other workers, however, do indicate that ponds are a risk to udder health (7). The contrasting viewpoints may be a result of purpose built ponds, often with moving water, which are managed versus natural ponds. Even with the managed ponds the bacterial numbers can be high with the potential for a problem (9). A study in Texas found that the bacteriology in bulk milk samples was not influenced by whether the herds used cooling ponds or were absent (13). SCC were also not affected.

With housing, the strategy is reliant on the provision of air movement in addition to shade and water, both drinking and for direct application to the cow. However, great care is needed as humid conditions or poor ventilation may make the heat stress situation worse. Additionally, it is imperative that overcrowding is prevented (1). Overcrowding reduces airflow over the cows, reducing their ability to get rid of heat, but also increases the heat generated in a given area.

The design of building must ensure correct air movement, i.e. correct inlet and outlet ventilation, to allow at least 10 changes in volume of the building every hour (6). For a 100 cow herd with feed and sleep building this means that any ventilation system must provide 30,000m^2 of air each air during the summer. This can be achieved by natural ventilation in well designed, constructed and maintained buildings. However, some authorities recommend at least one air change per minute (3). This will tend to be achievable where the roof slope is between 1 in 3 and 1 in 2, with open sides to the building

In summer roof insulation can reduce solar penetration dramatically, and is therefore recommended for collecting yards and parlours, since they have summer afternoon occupancy. Insulating roofs in the housing area should be given serios consideration where cows are housed throughout the year. The roof should be light in colour to reflect heat (solar radiation). Roof lights should also be positioned to minimise the solar radiation entering the building but still optimise natural light.

Even when the perfect building is in place, nature will need assistance to cool cows in periods of high ambient temperatures. There are several options. The most effective in bringing the temperature within a building to below the outside ambient temperature is refrigeration. However, this is very expensive and currently uneconomic. The alternative is evaporative cooling, whereby energy from the air is used to evaporate water. The disadvantage of this system is that it increase humidity levels, and with current UK conditions is likely to less effective than in more arid areas. The more complex, i.e. costly, systems are used in many greenhouses. More economical systems works by creating mists (larger water droplets) or fogs (smaller water droplet size) and as they evaporate they cool the air. When the animal inhales the cooler air, heat exchange occurs in the lungs, so removing heat from it's body. It is also important that the cows hair is thoroughly wetted down to the skin, otherwise an insulating layer is created so compounding the heat problem. Other recorded disadvantages are respiratory and pneumonia problems when cows are exposed for long periods (3).

The installation of fans, combined with spraying water onto cows can also be useful to increase evaporation rates as cows "sweat" and so dramatically reduce the effects of heat stress. The combination can also have benefits in fly control.

A study is the USA suggested that when ambient temperatures reached 27° C, the addition of fans and sprinklers in the collecting yard reduced the cow body temperatures by 1.7° C, with benefits to milk yield (6). However, spraying water within the housing environment is best avoided due to the implications of the dryness of the bed and the increased risks of mastitis as a consequence. Therefore the system is more suitable to areas such as the collecting yard while cows wait for milking, even when ambient temperatures are not excessive. Remember, when cows are closely confined in the collecting yard, ambient temperatures can rise rapidly. In practise udders may also become wet and so it is imperative they are dried as part of the teat preparation routine (4).

Other suitable areas for fans used in combination with sprinklers is in the dispersal yards and feed areas.

Changes to feed rations may be needed, such as providing a more energy dense diet to compensate for reduced intakes, being wary of not upsetting the forage:concentrate ratio. But in addition the mineral content may need adjustment to replace that excreted by the increased sweating by the cows (7). Cows receiving buffer feeding during hot summers should be offered high quality forage, thus requiring less intake to receive a balanced ration.

Increasing the amount of feed available during the cooler part of the day is also important - feeding 60-70% ration between 8pm and 8am has successfully increased milk production during hot weather. If the cows feed intake matches her requirements there is less chance of her being susceptible to diseases such as mastitis.

Additionally, heat stress can be reduced also by avoiding any stressful handling of cattle during the hottest time of the day.

SUMMARY

Heat stress can be a problem in the UK, and can lead to reduced cow performance, increased levels of mastitis and therefore lower profits. It has the potential to become an even greater problem with global warming.

Although heat stress can be a concern during our hot summers, the main cause of heat stress currently in Britain is often due to poor ventilation of cattle buildings in winter. This is likely to become worse with global

warming unless action is taken now, especially when modifying existing or constructing new facilities. Ventilation is critical but rarely given the attention it deserves.

Improving dairy cow facilities and management will not only improve the general health and welfare of dairy cows, it will also improve their performance, help to minimise the incidence of mastitis and maximise dairy enterprise profitability.

Finally, strict mastitis control procedures must be an integral part of heat stress management (4). Without a full and consistent mastitis control programme in place and consistently applied, such as the Defra Mastitis Management Action Plan, time, expense and effort invested in preventing heat stress will only be partially successful.

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THE IMPACT OF NUTRITION ON MASTITIS

A. J. Hayton BVM&S DCHP MRCVS
Kingfisher Veterinary Practice, Tower Hill Road, Crewkerne, Somerset, TA18 8EQ office@kingfishervets.co.uk

SUMMARY

The epidemiology of mastitis is still far from elucidated and the potential influence of nutrition on the aetiology of mastitis is still subject to debate. This paper will review the current understanding on the potential nutritional influences that may play a part in mastitis aetiology.

INTRODUCTION

Disease is a balance between challenge and immunity, with the exception of increased environmental contamination due to excessively loose faeces. If nutrition is to have an effect on the outcome of mastitis it will be via modulation of the cow's immune system. Immunity to mastitis is based either on anatomical defences or at the cellular and humoral level. Primarily, nutrition would be expected to influence the latter though higher planes of nutrition resulting in increased production may have an effect on the cows anatomical defences (due to the potential for a shortening and widening of the teat sphincter and thereby an increased chance of leakage of milk and penetration by pathogens whether during lactation or at drying off).

PHYSIOLOGICAL MECHANISMS

In the week before and after calving normal immune function is suppressed due to a reduction in the phagocytosing and killing ability of neutrophils, a reduction in the ability of lymphocytes to respond to mitogens and to produce antibody, and a reduction in the serum concentrations of important specific and non-specific components of the immune system such as immunoglobulin, complement, conglutin and lactoferrin. This reduction in immune fuction is postulated to be driven by the rise in plasma cortisol and oestrogen at this point (12). Similarly levels of the anti-oxidants important to immune function generally fall during this period, presumably partly due to sequestration into colostrum but also due to increased metabolic and immunologic stress at this point (13).

While some level of immunosuppression is normal, if deficiencies in energy and micro-nutrients exist, it is suggested that this may exacerbate the problem leading to increased disease susceptibility. The two main focuses of research on the effect of nutrition on udder health have been the effect of energy status and the influence of the micronutrients associated with anti-oxidation

ENERGY STATUS

The combination of the reduction in dry matter intake and the huge increase in the demand for energy at the start of lactation make negative energy balance (NEB) virtually ubiquitous in modern dairy cows at this stage of production. Most cows cope with NEB through an intricate mechanism of metabolic adaptation (16), where these adaptive mechanisms fail to cope, ketosis and fatty liver disease will occur. The risk factors for ketosis/fatty liver are well established and will not be reviewed within this paper. The occurrence of these conditions is widely recognised to be associated with increased peri-parturient disease (14, 9). There is a reasonable amount of evidence now from both epidemiological and experimental studies that the ability of the cow to resist intra-mammary infection is reduced when she is ketotic (25, 37). There are a number of mechanisms by which this reduction in efficiency is mediated:

- Neutrophil and macrophage phagocytosing ability is reduced
- Cellular recruitment reduced possibly due to reduced levels of cytokines produced by leucocytes
- Leucocyte chemotaxis is reduced

One study looking at energy status in the first 9 weeks of lactation demonstrated that 5% more cows had mastitis and 8% more cows had an elevated somatic cell count (SCC) if sub-clinically ketotic (≥1400μmol beta-hydroxybutyrate (BHB)) than if non-ketotic. Furthermore, controlling for all other factors, chronically ketotic cows were 1.7 times more likely to have an elevated SCC than cows that were not ketotic for two or more weeks in the post partum period (8).

Given the current understanding of the compromise to immunity in ketotic cows this finding is perhaps not surprising though it should be stated that not all papers have reached this conclusion. A recent paper by Berry *et al* (3) concluded that substantial amounts of body condition loss do not unduly compromise cow udder health.

The monitoring and prevention of ketosis in early lactation is the subject of a vast amount of research. Bobe *et al.* (4) identified several nutritional risk factors for the development of fatty liver (see table 1).

A full discussion of the aetiology of fatty liver and ketosis is out with the remit of this paper, though a brief discussion on the impact of short dry periods is pertinent given their topicality at present. Recent advances in our understanding of the development of insulin resistance due to both over-feeding in the early dry period (34) and the importance of avoidance of large reductions in dry matter intake at calving (12), *e.g.* due to excessive group changes, has in part lead to the consequent interest in the potential for shortened dry periods to resolve these issues.

Table 1: Risk factors for fatty liver in lactating dairy cows.

Prepartum:		
Obesity (BCS ≥ 4.0)	++	Wensing *et al.*, 1997
Severe feed restriction	+++	Gerloff and Herdt, 1984
Feeding excess energy	++	Wensing *et al.*, 1997
Long calving interval	+	Stober and Scholz, 1991
Postpartum:		
Diseases and infections	++	Katoh, 2002
Fasting	+++	Brumby *et al.*, 1975; Fu¨ rll *et al.*, 1993
Feed restriction	++	Staufenbiel *et al.*, 1992; Drackley, 1999
Ketogenic diets	+	Stober and Scholz, 1991
Sudden feed changes	+	Stober and Scholz, 1991; Gerloff, 2000

The number of + represents slight, moderate, and strong risk factors for fatty liver

The effect of shortened dry periods on udder health has not been fully elucidated. Cows with shortened dry periods compared to the conventional 60 days show less body fat mobilisation and decreased liver triacylglcerides post calving (32) which given the discussion above would suggest a positive advantage to udder health. Furthermore they will have a lower yield at drying off which has been shown to be a risk factor for the acquisition of new IMI during the dry period (30). In converse, it will both reduce the period of time where the udder is completely dry which is accepted as the time when the gland is most resistant to infection and potentially reduce the exposure to antibiotic dry cow therapy, thereby reducing the opportunity of removing pre-existing infections.

Recent papers by Kuhn *et al.* (21, 22) looking at field data over 6 years from US dairy cattle concluded that “herds with mastitis problems should be cautious in shortening days dry because short dry periods led to higher cell scores in the subsequent lactation compared with 60-d dry”, this being particularly true for the US Jersey. In contrast a study in Denmark by Enevoldsen and Sorensen (10) comparing 4, 7 and 10 week dry periods found no difference in clinical mastitis rate between the groups.

Given the current lack of understanding it would be advisable to only consider short dry periods where clinical and sub-clinical mastitis is not a problem.

MICRONUTRIENTS

Generally where micronutrients are related to immune function it is via their effects on the anti-oxidant system and as such generally there is an inter-relationship between them. The primary important components of this are:-

Vitamin A (retinol)

This is a fat soluble vitamin. Its role is not fully understood as an anti-oxidant but is involved in resistance to infection, particularly mastitis (29). Beta-carotene is also thought to have a role as an antioxidant separate to its role as the precursor to vitamin A (24).

In the cow, vitamin A is derived from its dietary precursor beta-carotene during metabolism in the intestinal mucosa. Green forages contain relatively high levels of beta-carotene but grain and grain by–products contain very low levels. Beta-carotene rapidly degrades and consequently silage and hay concentrations will be significantly lower than the fresh equivalent, with the length of time stored negatively correlated with concentration. Compounding the low vitamin A levels in non-forages is the increased levels of ruminal destruction of it as forage levels are reduced. Papers suggest that ruminal destruction of vitamin A can increase from 20% to 60% as forage levels decrease to 30-50% of the total diet (33, 38). Consequently supplementation will need to be highest on cows fed conserved forages on high levels of cereals and lowest on grazed grass.

Several studies have assessed the effect of supplementation of vitamin A and/or beta-carotene on udder health within the dry and peripartum periods (40). Dahlquist and Chew (7) demonstrated that cows supplemented from three weeks prior to drying off and continuing throughout the dry period with 53,000 iu/day of vitamin A plus 300 mg of B-carotene/day reduced the number of new intra-mammary infections (IMI) by approximately 50% in the early dry period as compared to low (53,000iu/day) vitamin A only or high (173,000iu/day) vitamin A supplementation (27% of previously uninfected quarters versus 49 and 50% respectively). When these same treatments were applied for three weeks prior to calving to 10 weeks post calving the vitamin A and beta-carotene combination again performed the best in respect of reducing mean somatic cell count in early lactation as compared to the low or high vitamin A supplementation (6).

In contrast Michal *et al.* (28) and Oldham *et al.* (31) found no evidence of an effect of supplementation of either vitamin A or a combination of both vitamin A and beta-carotene. This lack of response could be attributed to the status of the control cows in respect to vitamin A and carotene within the trials. The cows within the Oldham *et al.* trial had significantly higher levels of plasma beta-carotene than the cows used by Dahlquist and Chew (7).

Perhaps most interestingly LeBlanc *et al* (24) measured serum concentrations of vitamin A around calving and their associations with disease risk. They found that a 100ng/ml increase in serum retinol was associated with a 60% decrease in early lactation clinical mastitis (within the range of values that they observed; mean +/- SD = 191 +/- 76 ng/ml). However they concluded that there did not appear to be a simple threshold of vitamin A that is required and that complex interactions with other factors, principally the metabolic status of the cow around calving, are likely to determine the requirement.

The NRC recommendation for supplementation of vitamin A (29) for both dry and lactating cows is 110iu/kgbodyweight. For a 700k cow this is equivalent to 77000iu/day. (Toxic levels for vitamin A are reported to be above 66,000 iu/kg diet and therefore toxicity is unlikely to be a problem (National Research Council, 1987)). No requirement for beta-carotene has been set as this is a parameter not normally measured in the field. Beta-carotene is expensive and unless the diet is likely to be deficient supplementation is considered unlikely to be necessary (40). Supplementation of vitamin A should be specifically considered in diets containing high levels of concentrates, low levels of green forages, high levels of poor quality forages and during the periparturient period. Additionally, supplementation should be considered during periods where the immune system is under “stress” due to reduced competency or of high levels of exposure to infectious pathogens.

Vitamin E (alpha-tocopherol)

This is a fat soluble membrane anti-oxidant that enhances the functional efficiency of neutrophils by protecting them from oxidative damage following intracellular killing of ingested bacteria and also has a role in maintaining cellular membrane fluidity (24, 2). Like selenium, it also has a role in the metabolism of inflammatory mediators that are important for the initiation and amplification of the host response.

The levels of vitamin E within and between feedstuffs are very variable. As with vitamin A, vitamin E is highest in fresh forages and lower in conserved forages (silage and hay contain 20 and 80% respectively less vitamin E than fresh forage) (40). Similarly concentrates also tend to contain much lower levels. Prolonged storage will decrease levels of vitamin E. Unlike vitamin A ruminal metabolism of vitamin E appears minimal (38).

There are numerous studies investigating the effect of vitamin E on udder health (40). It has been demonstrated (Smith *et al* (36) and Hogan *et al)* (17) that feeding supplemental vitamin E at 1000iu/day during the dry period and 500iu/day during lactation significantly reduced the incidence and duration of IMI and clinical mastitis. Similarly Weiss *et al* (39) found that feeding the same levels of vitamin E in the dry period (1000iu/day) reduced clinical mastitis at calving by 30% and that increasing this to 4000iu/day for the last 2 weeks of the dry period resulted in an 80% reduction of clinical mastitis at calving and a 60% reduction of IMI. The influence of selenium status would appear to be taken into account however, as a study using very similar levels of supplementation by Batra *et al* (1) found no effect on clinical mastitis. However these cows were considered to be deficient in selenium.

LeBlanc *et al.* (23), in the largest randomised trial of parenterallv supplemented vitamin E in transition cows to date could not show an effect of raising vitamin E levels in reducing mastitis. They concluded that the difference in their trial from the reported effects of Smith *et al.*(36) and Weiss *et al.* (39) was that in their study the cows already had adequate vitamin E levels whereas in the other studies the control groups received little or no supplemental vitamin E.

As the basal diet will be highly variable in the level of vitamin E it contains, recommendations for vitamin E are based on the requirements for supplementation. In non-grazed cattle the current NRC recommendations for Holstein cattle are 1000iu/day for dry cows and 500iu/day for lactating cows. In grazed cattle these requirements are reduced to 330iu/day for dry and 160iu/day for lactating cows. There is limited data and anecdotal reports that increasing levels of supplementation of vitamin E in dry cows to 3000iu/day may be beneficial. This may be particularly true if there is evidence of increased periparturient disease or where there is an increased risk of this developing, *e.g.* cows too fat at calving or transition cows exposed to unfavorable environmental conditions. As Vitamin E is not considered very toxic supplementation at this level for a limited period of time is very unlikely to create a problem.

Vitamin C (ascorbic acid)

Vitamin C is water soluble and can quench free radicals and singlet oxygen and can also regenerate the reduced antioxidant form of vitamin E (2).

Further work is required to elucidate the potential prophylactic or therapeutic effects of supplementing vitamin C though there is some evidence that supplementation may prove beneficial. Kleczowski *et al.* (18) showed that cows with intra mammary infection (IMI) show reduced levels of vitamin C in their serum compared to non-infected cows. Similarly, Weiss *et al.* (41) showed that cows exhibited more severe infection when there was a greater reduction in vitamin A post challenge. However, in both these studies it is difficult to distinguish between whether this is merely a result of the infectious process or as a consequence of a failure in vitamin A supply. Chaiyotwittayakun (5) demonstrated that infusion of ascorbic acid post challenge with endotoxin improved milk yield recovery. Finally a recent paper (42) where cows received supplementation at 30g/day of vitamin C suggested that supplemental vitamin C did appear to reduce somatic cell count but appeared to have no effect on neutrophil activity.

At present there are no current recommendations for vitamin C supplementation.

Selenium

This mineral is required for the activity of the anti-oxidant enzyme glutathione peroxidase (2).

There are a variety of trials that have demonstrated a link between selenium supplementation and udder health (40). Both Malbe *et al* (26) and Wichtel *et al.* (43) demonstrated a reduction in somatic cell count when they supplemented selenium. Erskine *at al* (11) showed that cows supplemented with 2mg of supplemental selenium per day showed greater resistance to mastitis when experimentally challenged with *Escherichia coli* compared to the control cows on a diet with 0.04ppm selenium. Kommisrud *et al.* (19) concluded in their study on the association of blood selenium and health and fertility traits that there was a positive association between increased blood selenium concentration pre partum and decreased incidence of mastitis.

With reference to supplementation level Weiss (40) concluded that there was no clinical evidence for an improvement in udder health beyond a supplemental level of 0.3ppm selenium.

Copper

This mineral is essential for the activity of the superoxide dismutases (2). There is currently little peer reviewed work suggesting an effect of copper on udder health. Scalettii *et al.* (35) showed a reduction in the severity of clinical signs post infusion of *E. coli* in heifers supplemented with copper compared to the non supplemented control group. Similarly Harmon and Torre (15) showed a similar effect on supplemented versus non supplemented heifers with those receiving copper showing a reduction in IMI post calving and a greater resistance to an *E. coli* challenge. However, in both trials it is not unreasonable to question whether the relative difference between control and treatment group was due to the control being copper deficient rather than an effect of increased supplementation.

Given this and the paucity of data together with the potential for copper toxicity with over supplementation, the advice should be that copper supplementation should not occur unless there is clear evidence of copper deficiency within the diet.

Zinc

This mineral is also essential for the activity of the superoxide dismutases (26). As with copper there is a paucity of evidence to suggest an effect of supplementing zinc on udder health and the author is unaware of any peer reviewed work other than Whittaker *et al* (44) on the effect of zinc supplementation on udder health. There are a number of non-peer reviewed articles suggesting an effect on a reduction in somatic cell count when zinc was supplemented in the region of 360mg/day, however due to trial design this can not be definitively attributed to the effect of supplementation (40).

NRC recommendations for requirements for zinc are 300mg/day for dry cows to 1400mg/day for a cow producing 45 litres. Zinc can interfere with copper uptake and it is recommended that the dietary zinc intake should not exceed the dietary copper intake by more than fivefold.

Assessing Trace Element Status

Of the vitamins, only A and E have absolute dietary requirements. Provided that there is sufficient amount of the required micronutrient for optimal immune function then supplementation above this level will not further boost function (unless there is a relative deficiency of a related micronutrient, *e.g.* a low selenium level) and, in fact, over supplementation may be dangerous. The difficulty in practice in deciding appropriate levels of feeding is that we rarely know the initial contribution of the basal diet to the animal's requirements.

Even where NRC recommendations are followed it can not be concluded that appropriate levels are being reached as the NRC figures do not take into account the potential for antagonism of uptake, *e.g.* molybdenum and copper. In cases where the likelihood of toxicity and the cost of supplementation is low, such as with vitamin E, then it is probably easier to use a rate of supplementation that is sufficiently high that it should cover all eventualities. Where this is not the case it will be important to be able to accurately assess the trace element status.

As the major focus in improving udder health via nutritional status is during the transition period this is the most obvious time to sample. This rationale however is complicated by the fact that the serum level of these compounds tends to fall naturally close to calving.

Where the diet to the dry cows is constant, Swedish work (27) demonstrated that the blood concentrations of serum vitamin E and plasma selenium in the mid dry period significantly predicted the occurrence of values considered marginal or deficient at the time of calving. The data indicate that a mid dry period concentration of > or = 5.4 mg/l of serum vitamin E and > or = 0.09 mg/l of plasma selenium will result in a 90% chance that the cow stays above marginal levels at calving.

MISCELLANEOUS EFFECTS

There are a couple of recognised, but at present unquantifiable, potential nutritional related effects on mastitis. Firstly the report by Zadoks (45) that cows at grazing excreted Streptococcus uberis significantly more than when housed. There is similarly, anecdotal evidence for a variation in Klebsiella excretion, with a higher prevalence of shedding observed in the summer (on average 80% of animals) than in winter (ca. 10% of animals) (Zadoks, pers comm.). In the S. uberis study, the winter diet (silage, hay) was different than the summer diet (grazing), which suggests a role of the diet, especially as S. uberis was not isolated in haylage/silage but was in the grazing. However with the Klebsiella study the diet remained constant year round,

thus a difference in diet could not explain the observed difference in prevalence of faecal shedding.
Secondly, the potential impact of mycotoxicosis on mastitis. Mycotoxins are recognised to have potential immunosuppressive qualities (20) and there is reasonable anecdotal evidence that removal of contaminated feed or the use of absorbents has lead to the reduction of mastitis and cell counts on some farms. Consequently cows should not be fed overtly contaminated feed and where there is a suspicion of mycotoxicosis the use of an absorbent is sensible as. While costly, any effect will be seen relatively quickly which will then allow a decision as to whether to continue with the product.

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QUARTER AND COW RISK FACTORS FOR CLINICAL MASTITIS AND ELEVATED SOMATIC CELL COUNT IN U.K. DAIRY HERDS

J. E. Breen[1, 2], M. J. Green[3], A. J. Bradley[1, 2]
[1] School of Clinical Veterinary Science, University of Bristol, Langford, Bristol, BS40 5DU, UK
[2] Quality Milk Management Services Ltd., Unit 1, Lodge Hill Industrial Park, Station Road, Westbury-sub-Mendip, Wells, Somerset BA5 1EY, UK
[3] School of Veterinary Medicine and Science, The University of Nottingham, Sutton Bonington Campus, Sutton Bonington, Leicestershire, LE12 5RD, UK.

INTRODUCTION

Despite extensive research into risk factors for bovine mastitis, the incidence rate of clinical mastitis (IRCM) in the U.K. has remained static during the last 20 years and the most recent published work suggests that the mean incidence has increased to somewhere between 47 and 65 cases per 100 cows per year (1). As the pathogens causing mastitis have shifted away from contagious organisms spread predominantly during the milking process towards environmental pathogens that opportunistically invade the udder at any time, it is prudent to consider those risk factors applicable at the cow-level, which may determine an animal's susceptibility to infection. Particular emphasis was placed on observational measurements including hygiene scoring, teat-end scoring and assessment of body condition score, as these parameters can be modified or improved in disease control measures and are non-invasive, simple to perform and their use is encouraged within the current industry drive for herd health planning and individual animal-based assessments.

MATERIALS & METHODS

Eight dairy herds in the South-West of England, having an IRCM >35 cases per 100 cows per year were enrolled into a longitudinal study. Each herd received a monthly visit for a period of one year and at each visit, all cows in milk were scored for udder hygiene (4), teat end callosity (3) and body condition (2). The farmer recorded all quarter cases of clinical mastitis and individual cow somatic cell counts were available from National Milk Records (NMR). Outcomes used in the analysis were of first cases and all cases of clinical mastitis before the next visit, and SCC >199,000 cells/ml at the next recording. Statistical analysis included the use of generalised linear mixed models.

RESULTS

A total of 1677 cows were enrolled during the study period. For the final analysis there were 29282 udder hygiene scores (UHS), 53367 teat-end scores (TEC), 14074 body condition scores (BCS) and 929 cases of clinical mastitis (CM). Of cases of clinical mastitis that were sampled and submitted for culture, the environmental pathogens *Escherichia coli* and *Streptococcus* *uberis* were isolated in 171 (26.7%) and 121 (18.9%) cases respectively. Cow parity and month of lactation were significant independent variables for the occurrence of CM and elevated SCC. Allowing for the effect of herd, cows with very dirty udders and quarters with severe hyperkeratosis of the teat-end were significantly more likely to develop CM before the next visit during lactation compared to all other scores ($p<0.05$). Cows that recorded a BCS <1.5 or >3.5 in lactation were significantly more likely to record a SCC >199,000 cells/ml in the next month compared to all other condition scores ($p<0.05$). Cows with mild to moderate TEC scores were less likely to record an SCC >199,000 cells/ml in the next month ($p<0.05$).

CONCLUSIONS

These results suggest that individual quarter and cow risk factors are important in the acquisition of clinical mastitis and elevated SCC. Poor udder hygiene and severe teat-end damage were significantly associated with an increased risk for CM. Metabolic status, as measured by BCS, may also influence the rate of intramammary infection during lactation as measured by SCC.

ACKNOWLEDGEMENTS

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INITIAL STUDIES OF TEAT SPRAY APPLICATION FOR DISINFECTION

C. Kingston and R Hiley
Ambic Equipment Limited, Witney, Oxfordshire, England

INTRODUCTION

Sprays of disinfectant are commonly used as part of udder hygiene management programmes and are often applied using hand lances or automated delivery systems. The work described in this paper aimed at establishing an improved understanding of spray application to the udder using hand lances, so as to provide a basis for improving the overall process.

MEASUREMENT OF DROPLET SIZE DISTRIBUTIONS IN THE SPRAY

Droplet size distributions in the spray were measured by staff at Silsoe Spray Applications Unit (part of The Arable group in the UK) using two different instruments and a range of sampling strategies. A light scattering instrument (Malvern Instruments "Spraytec") was used to take integrated line samples through the spray and to study time dependent characteristics associated with spray establishment and collapse. A droplet imaging system (Oxford Lasers "VisiSizer") was used to examine the spatial characteristics of the sprays produced. Measurements were made with two different lance/nozzle combinations, one a fixed geometry cone nozzle and the other an adjustable hollow cone nozzle operating at pressures of 40, 50 and 60 psi (2.72, 3.40 and 4.10 bar) and with three different disinfectant liquids. Examples of the results of these measurements using the Malvern Instruments ("Spraytec") system are shown in Table 1.

The results show some consistent trends namely:

- the spray from the adjustable hollow cone nozzle gave a smaller mean droplet size (Dv_{50}) and a higher percentage of spray volume in droplets <100 µm in diameter than the fixed geometry cone nozzle;
- different disinfectant formulations gave very different droplet sizes when sprayed through the two nozzle types with disinfectant A having a droplet size distribution close to that of water and disinfectants B and C much larger mean droplet sizes;
- no substantial differences in the flow rates of the different formulations.

Table 1 Summary of the measured droplet sizes in the whole spray for the two nozzles operating with three liquids at a pressure of 50 psi (3.40 bar), - means of three replicates.

Nozzle geometry	Liquid	Flow rate		Dv_{50} µm	% spray volume <100 µm diameter
		US gal/min	l/min		
Fixed	Water	0.196	0.743	195.9	10.9
Fixed	Disinfectant A	0.202	0.766	187.5	12.6
Fixed	Disinfectant B	0.201	0.762	282.3	7.1
Fixed	Disinfectant C	0.200	0.758	322.9	5.7
Variable	Water	0.165	0.623	155.6	25.8
Variable	Disinfectant A	0.167	0.633	155.4	25.9
Variable	Disinfectant B	0.169	0.639	230.5	16.7
Variable	Disinfectant C	0.169	0.640	257.2	13.7

SPRAY DEPOSITION ON SIMULATED TEATS

A simulated rubber udder was supported in a laboratory environment and sections of chromatography paper were cut and wrapped around each teat in such a way that the inner and outer facing sections could be identified for subsequent analysis. The udder was then treated with a timed burst of spray from the two nozzle types positioned nominally 6.0 in (150 mm) below the udder and moved in a way that is typical of that used in application practice. The spray liquid was 0.2% of a soluble tracer dye with 0.1% of a non-ionic surfactant. After spraying, the chromatography paper was removed, sectioned and the deposits on each section recovered into a known volume of water. The volume of original dye captured was then determined by spectrophotometry calibrated with samples of the spray liquid taken from the nozzle at the time of application. The results showed considerable variation and little in the way of a consistent trend, but did suggest that higher deposits may be associated with larger rather than smaller droplets. Further work with more controlled movements of the nozzle in relation to the udder position is required to consolidate this indication.

CONCLUSION

The results of the study have shown differences in mean droplet sizes and the fraction of spray volume in inhalable droplets with nozzle type, pressure and spray liquid. Spray patterns were rapidly established following operation of the trigger valve and were very stable during spraying pulses of 1.0 to 5.0 seconds. Assessments of deposits on a simulated udder showed a high level of variability but some indication that there may be advantages of using a larger droplet size particularly if flow rates were not then increased.

FACTORS THAT AFFECT THE OPENING AND CLOSING OF THE LINER BARREL

D. Boast[1] and S. Long[2]
[1]Avon MDC, Brook lane Ind Est. Westbury, Wilts. BA 13 4 EP. Email dave.boast@avon-rubber.com. (corresponding author). [2] Avon Hi life, Wisconsin USA.

The movement of the liner is at the heart of the milking machine. When the liner closes it relieves the vacuum on the teat and applies a massage pressure to the teat. Liner wall movement sensors have been built, in order to understand the factors that affect the design and performance of the liner. Factors that affect the rate of movement are various dimensions of the liner but also the inertial properties of the milk within the liner.

Pulsation traces are commonly used to determine the health of the milking machine. The variation in pulsation pressure is the command that causes the liner to move. Measurements of liner wall movement have been made with infra red devices and compared with pulsation traces. Tests were done in a mechanical cow. Touch point pressure is primarily a measure of the bending stiffness of a liner barrel and would be expected to influence the rate of movement of the liner wall. No relationship between touch point pressure and liner opening and closing speeds has been found. The main influences of the rate of opening and closing of the liner is the inertial properties of the milk and the rate of pressure change in the pulsation chamber.

The liner does not even start to move till the end of the opening pulsation pressure phase (the "a" phase). Also, closing commences soon after the start of the closing ("c") phase (it takes very little pressure to move the liner compared with the milking vacuum). When pulsation remains unchanged, the closing rate is similar for most liners. The speed of opening is governed by how quickly the milk can enter the liner barrel (from the cow and backflow from the claw). Backflow is not desirable as infections can be carried in the milk.

Liner dimensions such as wall thickness and liner bore can have a large effect on the pressure needed to close a liner. For instance simply decreasing the liner bore from 22 to 19 mm roughly doubles the pressure needed to close the liner. However the forces to open and close the liner remain small compared with the force needed to accelerate and decelerate the milk during pulsation. A change in flow from 4l/min to 6l/min (for 4 quarters) increases the open ("b") phase by 10% due to the reduced opening time because the milk is flowing into the liner more quickly.

Touch point pressure may indicate if the liner has changed in some way. However it is of little value as a measure of an important liner property that can be related to milking performance. Graphs of pulsation pressure also can indicate machine problems but are not a reliable indicator of the true motion of the liner.

PERSISTENT HIGH CELL COUNT COWS: WHERE DO THEY START, WHERE DO THEY GET TO?

J. Hanks[1] and A. Biggs[2]
[1] Veterinary Epidemiology & Economics Research Unit, University of Reading, RG6 6AR
[2] Vale Veterinary Laboratory, Tiverton, Devon EX16 4LF

Individual cow somatic cell counts (SCCs) are commonly presented as lists in descending order of the SCC magnitude. The attention of both farmer and veterinarian is drawn to those animals at the top of the list with the highest SCCs. These cows often have long established infections that consequently do not respond well to treatment and leave farmers unimpressed with regard to the expense and poor results obtained.

Monthly milk recording provides a readily accessible means of studying the dynamics of SCCs. Milk records of 585,277 cows from 5,174 herds were obtained from herds that milk recorded with NMR during a 7 week period in December 2006 and January 2007.

A measure of 200,000 cells/ml milk was used as a threshold to distinguish between “high” and “low” SCC measures. Cows with consecutive high SCC recordings were classified as “chronic” high SCC cows. As the study was targeting the dynamics of infection, the study population was limited to current chronic cows with at least one low SCC measure earlier in the current lactation. The change from low to high was taken as an indication of acquired infection during the lactation.

The distribution of the latest SCC measure indicates the range of SCCs across established chronic cows. Tracing back through the sequence of high SCC to the initial high SCC measure indicates the range of first high SCCs in cows that go on to be chronic high SCC cows.

70% of the chronic cows started their sequence of high SCCs with a measure below 500,000 cells/ml. The latest SCC of 60% of chronic cows was below 500,000 cells/ml. These results suggest that the majority of chronic cows begin and persist at a level that is routinely ignored.

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PERCENTAGE SOMATIC CELL COUNT CONTRIBUTION: HIGHLIGHTING THE WRONG COWS.

A. Biggs[1], J. Hanks[2]
[1] Vale Veterinary Laboratory, Tiverton, Devon EX16 4LF
[2] Veterinary Epidemiology & Economics Research Unit, University of Reading, RG6 6AR

The percentage somatic cell count contribution (%SCC) is commonly used by farmers and others to prioritise cows when tackling raised somatic cell counts (SCC). While %SCC does highlight the cows contributing most SCCs to the bulk tank, it highlights a disproportionate number of cows with long established infections that are less likely to respond to treatment. Cows with emerging infections are under emphasised, allowing their infections to develop unhindered.

A dataset of 570,987 cows was generated from 5,104 herds which were milk recorded during January 2007. Individual %SCCs were calculated for all cows. All cows were categorised as either included or excluded from the top 10% of cows by SCC% (Top10%). Milk recordings with SCC readings over 200,000 cells/ml milk were classified as “High”. The number of consecutive high SCC recordings before and after the January recording were also determined for each animal.

While overall 50% of high SCC cows were recording their first high SCC, when restricted to the Top10% this reduced to 44%. In contrast, 31% of cows overall were recording their third or higher consecutive high SCC increasing to 37% in the Top10%.

The overall percentage of cows maintaining a high SCC value at the **following** milk recording rose with the number of consecutive high SCC. While high SCCs persisted in 33% of cows recording their first high SCC, this rose to 50% of cows with two consecutive high SCCs, and 61% in cows with three or more consecutive high SCCs.

Emphasising the %SCC results in the majority of cows with an initial high SCC being ignored. In this dataset, taking cows in the Top10% excluded 63% of the cows with an initial high SCC that went on to have a raised SCC at the following recording. The %SCC results in most cows avoiding detection until an infection is well established with a reduced likelihood of cure.

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PRELIMINARY FINDINGS OF THE CEPHAGUARD DAIRY HERD MASTITIS INVESTIGATION SCHEME

Mandy Boddy and Andrew Biggs
The Vale Veterinary Laboratory, The Laurels Station Road Tiverton EX16 7RT

The identification of the types of potential mastitis causing bacteria present in milk samples, from both clinical and sub clinical mastitis infections on dairy farms, and their relative prevalence and important are a significant part of the approach to any mastitis herd investigation or development of a herd health plan. This investigation scheme was subsidised and allowed private veterinary practices to submit 20 milk samples for diagnostic purposes. The 20 samples were generally 5 samples from clinical cases, either sent in fresh or batched up by freezing along with 15 fresh samples from high somatic cell count cows - sub clinical samples. There are limitations to the diagnostic significance of a single culture from a cow with a raised somatic cell count however for the purposes of this investigation pure cultures were taken to be causal.

The results are presented showing prevalence of bacterial type in two distinct data sets (clinical cases and sub clinical cases). Samples with no identification of either clinical or sub clinical are omitted from the data. The scheme is still ongoing and the data will be updated on the day but to date is as follows.

Clinical samples (n = 762)
Streptococcus uberis 20%
Staphylococcus aureus 9%
Coliform 17%
No growths or non significant growths 37%
Coagulase negative Staphylococci 4%
Coynebacterium bovis 3%
Streptococcus dysgalactiae 2%
Contaminated 8%

Sub clinical samples (n = 3733)
Streptococcus uberis 14%
Staphylococcus aureus 11%
Coliform 14%
No growths or non significant growths 30%
Coagulase negative Staphylococci 6%
Coynebacterium bovis 9%
Streptococcus dysgalactiae 3%
Contaminated 13%

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IS MASTITIS PAINFUL?

J.N. Huxley[1] and H.R. Whay[2]
[1]School of Veterinary Medicine and Science, University of Nottingham, Sutton Bonington Campus, Loughborough, Leicestershire, LE12 5RD, UK
[2]Division of Farm Animal Science, Bristol Veterinary School, Langford House, Langford, Bristol, BS40 5DU, UK

INTRODUCTION

Assessing pain in animals is extremely difficult because pain is a private experience and animals communicate the levels of discomfort they feel in ways that can be difficult for us to interpret and quantify. We rely on indicators such as behavioural changes or markers of a stress response to identify whether animals are suffering. Research work has demonstrated that the heart rate, respiration rate and the hock-hock distance of cows with mastitis are significantly higher than in normal animals (3) and that mediators of inflammation and pain such as bradykinins are elevated in quarters suffering from all grades of mastitis (1).

Experienced animal workers can make value judgements in order to gauge the level of pain an animal is suffering. In these circumstances it is likely that observers draw on their experience of assessing a range of indicators including behaviour, posture, demeanour and other cues. Questionnaire surveys can be used to draw together the experience of such observers; over recent years they have been used extensively in veterinary medicine to assess the views and attitudes of stakeholders to a range of issues (including estimations of pain).

METHODOLOGY

A questionnaire investigating the experience and attitudes of respondents to pain and the use of analgesics in cattle was distributed to 2391 named cattle veterinary surgeons (4, 2) and 7500 named cattle farmers in the UK. As part of the survey respondents were asked to estimate how painful they thought two grades of mastitis were on a ten point pain scale (1 – No pain at all; 10 – The worst pain imaginable). The grades specified were “Clots in milk only” (Grade 1) and “Acute toxic *Escherichia coli* mastitis” (Grade 3). Data from the returned questionnaires were entered into Excel 2000 (Microsoft) and audited using several check methods. The data were manipulated and analysed using Access and Excel 2000 (Microsoft).

RESULTS

Results from questionnaires returned by 615 veterinary surgeons and 939 farmers were available for analysis.

The pain scores assigned to cows with mastitis causing clots in milk only were remarkably similar between both vets and farmers. The median pain score estimated by both groups was 3 (Table 1). Similarly the pain scores assigned to a case of acute toxic *E. coli* mastitis were similar between the groups, although the median score assigned by farmers (8) was slightly higher than that assigned by vets (7, Table 1).

Table 1 Median, range, quartiles and mode values of the estimated severity of pain associated with two grades of mastitis

	Grade of Mastitis	Median	Range (Min)	Range (Max)	1st Quartile	3rd Quartile	Mode
Vets	Clots in milk only	3	1	10	2	4	2
	Acute toxic *E. coli* mastitis	7	1	10	5	8	7
Farmers	Clots in milk only	3	1	10	2	5	2
	Acute toxic *E. coli* mastitis	8	1	10	6	9	8

DISCUSSION

Whilst the results provided here are subjective estimates, they are the combined estimates of a very large number of individuals with the most practical experience of bovine mastitis. They indicate that mastitis is considered a painful condition ranging from 3 to 8 on a ten point pain scale for the mildest through to the most severe forms.

There is a growing weight of evidence that mastitis is a painful condition. Those of us working in the dairy industry should be striving firstly to reduce the number of cases of mastitis that occur and secondly to control the pain caused when cases do arise. Currently, NSAIDs are the only suitable products licensed within the EU to control the pain associated with mastitis and their usage for this indication should be encouraged.

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DESCRIPTION OF MILK SOMATIC CELL COUNTS IN THE UK USING A NATIONAL DATASET

A. Madouasse[1], J N Huxley[1], W J Browne[2], A.J. Bradley[2] and M.J. Green[1]
[1]School of Veterinary Medicine and Science, University of Nottingham, Sutton Bonington Campus, Loughborough, Leicestershire, LE12 5RD, UK
[2] Bristol Veterinary School, Langford House, Langford, Bristol, BS40 5DU, UK

The aim of this analysis was to describe somatic cell count (SCC) patterns in a large sample of UK dairy herds and to assess differences between herds.

The dataset comprised a subset of milk recordings from National Milk Records (NMR, Chippenham) carried out between the 1 January 2004 and 31 December 2006. Herds were selected if they recorded on a monthly basis at two consecutive milkings. The dataset contained 6.9 million cow-test day recordings from 1,839 herds. Individual cow SCC were transformed using a natural logarithm. Test day bulk milk SCC were estimated by weighting individual cow SCC with their corresponding milk yields. A threshold of 200,000 cells/ml was used to categorise cows as “uninfected” or “infected” (1). Using this threshold, we looked at the dynamics of infections within herds. Prevalence of infection was defined as the percentage of cows above the threshold at a specified time point. The new infection rate was defined as changes from below to above 200,000 cells/ml and the cure rate as changes from above to below 200,000 cells/ml between consecutive tests.

The distribution of individual cow SCC was highly skewed and the log transformation partly normalised it. However after transformation this variable appeared to be bimodal; this is currently the subject of further investigation. Distributional characteristics of SCC are provided in Table 1. The effects of parity and lactation stage were investigated by plotting the lactation curves by parity. SCC reached a minimum between 30 and 45 days in milk. First parity cows had a lower and flatter curve. For higher parity cows, the curves had the same shape but were on average 40 to 50,000 cells/ml higher per lactation. Older cows also exhibited a greater variability between test days.

Estimated herd somatic cell count arithmetic and geometric means were 204 and 186,000 cells/ml respectively. The percentiles are given in Table 1. A three months herd rolling geometric mean SCC was calculated and averaged per month in order to compare it with figures provided by MDC datum. The data are consistent with the MDC figures; they show average SCC below 180 cells/ml between November and February and above 190 cells/ml between June and August. We also observed an increase of approximately 10,000 in SCC levels between 2004 and 2006. Average herd prevalence, infection and cure rates between January 2004 and December 2006 were calculated. Percentiles are given in Table 2. A slight increase in prevalence and new infection rates (~1.5%) was observed between 2004 and 2006, a decrease in cure rate (~0.9%) between 2004 and 2005 and an increase in cure rate in 2006.

The preliminary results described here outline some interesting SCC patterns in UK dairy herds. This analysis is part of an ongoing study investigating the relationships between SCC and a number of cow and farm level variables in this extensive data set.

Table 1 Means and percentiles for individual cow SCC and estimated bulk milk SCC count from 6.9 millions cows in 1,839 UK dairy herds

	Mean (1000 cells/ml)		Percentiles						
	Arithmetic	Geometric	5%	10%	25%	50%	75%	90%	95%
CSCC	221	93	15	21	39	85	199	463	817
BMSCC	204	186	87	105	141	189	250	319	371

Table 2 Percentiles for herd prevalence (%), new infection rate (%) and cure rate (%) for all recordings between the 1 January 2004 and the 31 December 2006 in 1,839 UK dairy herds

	Percentiles	All	Lactating cows (> 35d into lactation)	First recording after dry period (≤ 35d into lactation)	Heifers' first recording
Prevalence	5%	12.4	12.3	10.1	6.7
	10%	14.7	14.7	12.2	8.9
	25%	19.1	19.1	15.9	12.5
	50%	24.7	25.0	21.1	16.9
	75%	29.9	30.4	26.1	22.0
	90%	35.5	36.2	31.5	27.0
New infections	10%	8.0	7.5	8.8	
	25%	10.0	9.5	12.2	
	50%	12.6	12.2	16.5	
	75%	15.3	14.9	21.4	
	90%	18.4	18.1	26.2	
Cures	10%	27.7	23.3	59.6	
	25%	31.4	26.7	66.7	
	50%	35.8	31.3	73.2	
	75%	40.7	36.5	79.7	
	90%	45.8	41.6	84.4	

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IMPROVING TEAT END HYPERKERATOSIS

T. McKendrick
The Dairy Group, New Agriculture House, Blackbrook Park Avenue, Taunton, Somerset, TA1 2PX tim.mckendrick@thedairygroup.co.uk

There is strong evidence that a greater degree of teat end hyperkeratosis increases the risk of clinical mastitis in dairy cows (1).

An international teat scoring system has been devised by the members of Teat Club International (2) and is now widely in use in the dairy industry. For routine field evaluation, teat ends can be considered to fall into four classes:

- No ring (N)
- Smooth ring (S)
- Rough ring (R)
- Very rough ring (VR)

Monitoring the levels of hyperkeratosis in the herd enables the farmer and his advisors to assess the risk to the herd. Where hyperkeratosis levels are high, particularly in conjunction with a high herd mastitis incidence, there is a real incentive to investigate and to take appropriate action to improve it.

Many factors have been identified that contribute to teat end hyperkeratosis (3). The primary causes and exacerbating influences effecting teat end hyperkeratosis that have been identified include:

- High milking vacuum; long pulsation "d"-phase; high liner compression; high liner tension; long dribble times; over milking; chemicals, and cold, wet, windy conditions.

FARM STUDY

Regular teat scoring has been carried out between January 2005 and April 2007, on a large dairy farm in Somerset milking 700 cows, as part of the farm's mastitis control programme. In January 2005 it was found that 24% of the herd's teats were showing greater levels (R or VR) of hyperkeratosis. Discussions were held on farm between the farmer and his advisors and action taken. However by November 2005 very little change had been noted (22.9% of teats now at score R or VR). Herd mastitis levels were higher than the farm found acceptable.

Over the next twelve months some major changes occurred on the farm. The most significant of these was that the majority of the herd was now milked 3x/day and that the milking machine pulsation system and ACR controllers had been updated.

The next herd teat scoring was carried out in October 2006. It was found that 39.2% of teats were showing scores of R and VR. This significant deterioration caused real concern and action was immediately taken to identify the likely reasons and the action required to reduce the level of hyperkeratosis. The herd's mastitis incidence was running at around 100 cases per 100 cows with over 60% of the cows being infected during a lactation.

The ACR settings on the new ACR controls were identified as having a maximum milk flow setting of detachment of 300g/min with a 5 second delay. With the majority of cows now on 3x/day milking, the total amount of time clusters were attached at low milk flow (<1kg/minute) was significantly increased compared to 2x/day milking. Discussions were held with the equipment manufacturer and alterations made to the ACR control, allowing the settings to be increased to detachment at a flow rate of 400-450g/min with a 5 second delay. This work was carried out in January 2007.

Efforts were made to further improve the milking routine, immediately after the teats were scored and although routines were of a good standard before, special attention was given to ensuring a 15–20 second stimulation and 60-90 seconds prep-lag time.

The herd teat scoring was repeated again in April 2007 and 17% of teats were found with scores of R and VR. Mastitis levels had been monitored over this period and found to have greatly improved. Whereas around 10% of the herd was infected during October 2006, this had dropped to approximately 5% by June 2007, with the fall being consistent. Further monitoring will be carried out to see if the improved trend continues.

Table 1 Cases of mastitis treated per month – July 06 - June 07

Month	July '06	Aug '06	Sept '06	Oct '06	Nov '06	Dec '06	Jan '07	Feb '07	Mar '07	Apr '07	May '07	June '07
Cases treated	66	68	76	70	62	54	62	75	65	46	40	35

CONCLUSION

The results from the farm help support the argument for regular monitoring of teat end condition, to identify when changes occur. If teat end hyperkeratosis increases it is important to investigate the causes and carry out the action required to improve the situation. Teat end scoring is a very powerful tool, which should be carried out at least every 12 months on all dairy herds.

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PRACTICAL GUIDE TO AVOIDING MILK ANTIBIOTIC RESIDUES

The Milk Quality Forum
Dairy UK, NOAH and MDC, c/ 3 Crossfield Chambers, Gladbeck Way, Enfield, Middlesex, EN2 7HF

A poster has been created as an aid to dairy farmers in order to help prevent antibiotic residues in milk and to maintain the excellent high standards of milk quality in the UK.

The original details of the poster were drafted by Ben Brearley, MRCVS and then finalised into the current version with inputs from all members of the Milk Quality Forum, Chaired by Brian Peacock of MDC. The project was co-ordinated and managed by Phil Sketchley from NOAH.

The poster will be distributed to every dairy farmer in the UK (approximately 24,000), thanks to the support of NMR and the numerous milk collection companies.

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