BEDDING SYSTEMS AND MASTITIS
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SUMMARY
During recent years a change seems to have taken place in the proportion of different types of pathogens causing clinical mastitis. Environmental pathogens associated with bedding appear to predominate on many farms. Straw yards are often preferred to cubicles for welfare and comfort but appear to present an increased risk of intramammary infection. During an attempt to assess the risk of mastitis, when straw was used as a bedding material, it became obvious that the nutritional status of the cows, as indicated by the consistency of the faeces, is the origin of the major environmental challenge to cows. This occurs whether the cows are housed in cubicles or straw yards.

MASTITIS PATHOGENS
Despite the dramatic fall in bulk milk cell counts over recent years, and the lower incidence of contagious mastitis caused by Staphylococcus aureus, Streptococcus agalactiae and Streptococcus dysgalactiae, mastitis continues to be one of the most important diseases of dairy cows. The financial losses incurred remain unaffordable as is the distress and disappointment when a really good animal is ruined for at least a lactation.

Emphasis is now on environmental pathogens, principally Escherichia coli and Streptococcus uberis. Traditionally they have been bracketed, but in practice they are distinct in many important ways.

*Escherichia coli*
This organism is derived from faeces and survives in dirty and wet conditions. Soiled bedding, feed passageways and collection yards are contaminated. The bacteria survive poorly on skin and are rapidly eliminated from the mammary gland. They are viable at 15-45°C and grow optimally at 37°C. They thrive in acidic conditions but can tolerate alkalinity up to pH 9.5.

*E. coli* rarely causes sub-clinical mastitis but are a major cause of clinical mastitis. Infections can vary in severity from the mild case to a systemic toxaemia resulting in death. Often the most severe cases occur in recently calved cows. *E. coli* is poorly controlled by teat disinfection and dry cow antibiotic treatment. Prevalence appears highest in low cell count herds.

Invasion of the mammary gland may occur when milk droplets impact on a dirty teat end due to irregular vacuum fluctuations during milking. Selection for faster milking cows having a wider streak canal may have increased susceptibility.

*Streptococcus uberis*
This organism is more ubiquitous than *E. coli*. It can be isolated from teat skin, lips, vagina and faeces of the cow as well as causing sub-clinical mastitis. It seems to survive well in bedding and tolerates a wider temperature and pH range. Intramammary infections are reported most commonly near calving but sub-clinical infections can have a long duration. Infections are often intractable to antimicrobial therapy. It has been suggested that the prevalence of chronic Str. *uberis* infections is increasing.
Both *E. coli* and *Str. uberis* are always present in the bovine environment and proliferate in most bedding materials, especially straw. Controlling exposure to these pathogens by limiting environmental survival remains vital for the dairy farmer.

**BEDDING MATERIALS**

**Cubicles**
The UK dairy farmer usually only has access to sand, sawdust or straw for bedding. Research has clearly shown that the best material is washed sand. It is inert and provides no means for bacteria to grow and so minimises exposure of the teat end.

There is considerable evidence that both *E. coli* and *Str. uberis* readily invade the mammary gland during the dry period and cause new infections. Often these are only apparent at calving or soon afterwards when clinical mastitis occurs. There is a very strong argument for careful control of bedding of dry cows. This could be housing dry cows and heifers in well designed, sand-bedded cubicles and transferring them at calving into a box bedded with 15 cm (6 in) sand topped with clean straw.

Traditionally, calving outside in a paddock has been considered the safest option but in wet spring and autumn conditions sand cubicles are better.

Although sand has considerable advantages as a bedding material, large scale use can create problems with storage and handling of slurry. The sand in the bed must be conditioned daily and replenished often enough to keep it level with the kerb. One 1000 cow herd in Australia now uses a tractor mounted with a spiked arm to harrow daily the sand cubicles.

The common bedding alternatives, straw and sawdust, may provide a deep and soft bed but they have always presented a risk of more environmental mastitis. Straw and sawdust can, however, be used relatively safely as litter on mats covering concrete beds. Then there is little depth to the bedding and less bacterial contamination. As neither *E. coli* nor *Str. uberis* multiply in material above pH 9.5, solid beds dusted daily with lime before adding sawdust or chopped straw can be fairly safe.

**STRAW YARDS - A STUDY**

Straw yards as a housing system for dairy cows offer many advantages for welfare, especially in the control of lameness and the reduction of stress. The downside is the increased risk of environmental mastitis. A study has been undertaken, funded by the Milk Development Council and carried out in association with the Liverpool University Faculty of Veterinary Science, on selected farms in Cheshire. This has evaluated straw as a bedding material for the loose housing of dairy cows. Preliminary findings are reported here.

The type and quality of straw used to litter loose yards is obviously important. Barley straw seemed superior to wheat straw but much depends on the harvesting, storage and transport. Ideally straw should be stored under cover and moisture content should not exceed 15%. Although bales often appear normal there were occasions when these normal, bought-in, bales tested at more than 30% moisture (Figure 1, # middle of bale, > edge of bale)). Not only is such material useless for bedding but it is extremely expensive since more than one third of the
purchase is water! Devices are available to test the moisture content of straw and these seem to be good investment. Overall a moisture content of 15% or less is needed. The straw needs to be dried if the moisture is 15-20% of weight. Bales with more than 20% moisture must not be used.

Manual distribution of straw in the yard is an unpleasant task for those doing it as well as being wasteful and inefficient. Mechanical shredders condition the straw better, leaving it open and fluffy which makes an important contribution to keeping cows clean. Best use of straw is made by applying one third of the daily quantity in the morning and two thirds at night. The overall quantity for 180 days housing should be 2.5 tonnes per cow.

When examined weekly from the start of a new bed to the time of cleaning out there was virtually no occasion when the top surface did not support a population of \textit{E. coli} and \textit{Str. uberis} of at least $10^6$ per gram. This is considered a level at which there is a significant exposure to the teat ends. \textit{E. coli} and \textit{Str. uberis} survive and multiply at 15-45°C. It was found that within 14 days of establishing a new bed the layer of bedding immediately below the surface (5-7.5 cm, 2-3 in) reached optimum growth temperature (37°C) and remained at that temperature until the next clean out. The more heavily contaminated beds, generally accommodating high yielding, freshly calved cows, were quicker to heat up. The sub surface strata increased in depth as the weeks progressed to the next clean out and generated a considerable amount of heat. The heat carried the moisture as it passed to the more surface layers. After 4-6 weeks the base layer was relatively dry.

This ‘rising damp’ effect indicates the importance of good ventilation in a straw yard. The rising heat and moisture need to be dispersed as quickly as possible if the surface of the bed is to remain dry and cool. When the heat and moisture rise and the moisture is allowed to condense and drip back on to the bed the consequences are obvious. Even with the best means of natural ventilation problems can arise, e.g. on very still days in winter when the relative humidity outside is very high there is no escape of moisture from the building. On these occasions the surface of the bed can reach 98-100% relative humidity - a very sweaty bed develops. It is possible that the peaks

\textbf{Figure 1.} \textit{Average moisture content (%) of straw bales}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Average moisture content (%) of straw bales}
\end{figure}
of environmental mastitis coincide with these occasions. It may be necessary, as in many countries where cows are housed for long periods, that mechanical air extraction is necessary.

An attempt was made to control bacterial growth in the bed surface by means of additives. Lime was used as the primary product to raise the pH to a level inhibitory of growth by *E. coli* and *Str. uberis*. Using control and test beds, increasing amounts were added over a six-month period and the response measured in terms of bacterial numbers. Unfortunately, to raise the pH sufficiently to limit the growth of *E. coli* and *Str. uberis* a daily application of lime of approximately 400 g/m² was required. At this level it was not acceptable to the operators spreading this on the bed. There was a major problem in treating adequately and evenly with such a large volume of lime each day. The situation is different in cubicles and a sufficient application can be made.

**Nutritional aspects**

When considering all of the aspects of bedding and mastitis it was clear in this study that the dominating factors, affecting the condition of the bedding, the cleanliness of the cows and the pathogen load, were the stage of lactation of the cows and their nutritional status. This is shown by the consistency of the faeces. The dung pat from a healthy and fit cow should be firm enough to stand with a dip in the centre and a petalled surround. Correctly fed cows producing 9000 litres of milk will produce faeces of this consistency. Unfortunately, when formulating rations, there has crept in an acceptance that high yields are synonymous with thin faeces, often diarrhoeic cows. Animals in this state tend to have soiled tails and paint faeces on to the flanks and udder. These faeces also splash on to legs and the udder especially when cows are crowded in passageways and collecting yards. Straw yards and cubicles can be pristine clean yet the cows are unacceptably dirty and always highly exposed to mastitis pathogens.

**Cow cleanliness**

During the study the state of cleanliness of the cows in some high yielding groups became a matter of concern. Although all herds were under similar management, there was an interesting difference in the overall cleanliness of cows between the individual herds. Also, a marked difference was noted in the condition of freshly calved animals and those just before calving. Because of these factors, it was considered necessary to find some way of comparing cleanliness of cows in the different straw yards being observed.

Looking at individual cows it is easy to define a cow as clean or dirty but much more difficult to provide a herd assessment for statistical comparison. The method devised provides a score from 1 to 5 for cows in each herd. The scores relate to flanks, legs, udders and tails (Table 1).
Table 1. Percentage of cows at cleanliness scores 1 or 2, 3 and 4 or 5

(a) dry cows

<table>
<thead>
<tr>
<th>Herd</th>
<th>n</th>
<th>Flank 1, 2 3 4, 5</th>
<th>Leg 1, 2 3 4, 5</th>
<th>Udder 1, 2 3 4, 5</th>
<th>Tail 1, 2 3 4, 5</th>
<th>Cow 1, 2 3 4, 5</th>
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<td>112</td>
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<td>95 4 1</td>
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<tr>
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<td>66 32 2</td>
<td>50 48 2</td>
<td>67 32 1</td>
<td></td>
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<tr>
<td>3</td>
<td>165</td>
<td>66 28 4 73 25 2 90 8 2</td>
<td>89 10 1</td>
<td>94 6 0</td>
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<td></td>
</tr>
<tr>
<td>5</td>
<td>261</td>
<td>71 25 4 61 35 4 82 15 3</td>
<td>67 28 5</td>
<td>92 8 0</td>
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(b) high yielding cows

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<th>Udder 1, 2 3 4, 5</th>
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</table>

On each farm the dry cows were substantially cleaner than early lactation cows although management was similar. The difference is likely to be associated with the volume and consistency of faeces. Herds 2, 3 and 5 had an unacceptable proportion of dirty cows and this may be related to nutritional status. Hygiene apart, if environmental mastitis incidence is related to exposure to faeces then herds 2, 3 and 5 were especially at risk.

**Space allocation**

To minimise the exposure to mastitis pathogens in the bedding the stocking rate for straw yards, actual bedded area available, should vary with stage of lactation rather than simply cow numbers. High yielding, freshly calved cows need at least 6.5 m² (70 ft²) each, 5.57 m² (60 ft²) is adequate for mid and late lactation cows and dry cows can remain clean on 4.6 m² (50 ft²). This space is related to the quantity and consistency of faeces and the quantity of urine produced.

There is a similar relationship in cubicle housing for the cleanliness of cubicles, bedding and cows. An increasing number of herds have limited grazing and are housed for longer. Cows are now bigger and consume more food. In consequence, the traditional movement and feeding passageways are too narrow. Movement passageways now need to be 3 m (10 ft) wide and feed passageways 4.6 m (15 ft) wide if cows are to avoid splashing of the legs and udder and the cubicle beds are not to be soiled from feet. When the cow lies one foot invariably touches the udder and so teats may only be as clean as the feet. Slatted floors and more use of automatic scrapers may also help.
CONCLUSIONS

1. A greater proportion of clinical mastitis is caused by environmental mastitis when cell count is reduced.

2. All traditional bedding materials, with the possible exception of sand, are reservoirs of environmental mastitis pathogens and exposure can only be reduced by good management.

3. The major factor influencing the level of exposure is suggested as the nutritional status of the cow measured by the consistency of faeces.

4. A successful and safe bedding system requires good ventilation, adequate space, a good diet and efficient slurry control especially if sand bedding is not used.

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