The Influence of the Winter Environment of the Dairy Cow on Mastitis

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Objectives

To determine:

a) the influence of bedding temperatures in straw bedded cubicles (free stalls), on *E. coli* populations in bedding;
b) the relationship between the appearance of used cubicle bedding and its *E. coli* population;
c) the influence of *E. coli* in bedding on udder infections.

Methods

Thermocouple continuously measured temperatures in cubicle (free stall) bedding throughout 20 weeks of winter.

Each of 96 cubicles was classified once a week according to a 0 to 9 scale, based on cleanliness and 100g. samples of used bedding were collected from standardized sites in cubicles with the mode score of the visit and their *E. coli* populations determined by MPN techniques.

E. coli numbers were determined weekly on swabs from hind teat apices of 20% of the herd under study. Milk samples from clinical mastitis cases were cultured and monthly cell counts and plate counts on bulk milk were carried out.

Results

1) Reductions in environmental temperatures were followed by a 50% increase in the time cows spent lying down in cubicles (free stalls) and bedding temperatures above 35°C were then reached. Bedding samples from these cubicles had high *E. coli* populations.
2) Visual scores of cubicle bedding did not relate to their *E. coli* populations.

Conclusions

1) Environmental changes affect cow behavior and increase the possibility of udder infections.
2) Visual assessment of the potential bacterial challenge from cubicle (free stall) bedding is inaccurate unless supported by bacteriology.
3) High *E. coli* populations in bedding were associated with contaminated teat apices and clinical mastitis.

Introduction

During investigations into mastitis outbreaks, the authors encountered various environments which may have exacerbated the disease, but their effects were difficult to quantify. A study was therefore undertaken to attempt to determine, from detailed observations, the relationship between the climate in cubicle houses and *E. coli* populations in cubicle bedding, and the influence of *E. coli* bedding populations on teat apex contamination and clinical *E. coli* mastitis.

The pathogenesis of coliform mastitis is not entirely clear. Neave and Oliver and MacDonald and Packer have shown a positive correlation between infection deposited on the end of the teat and infected quarters. Jasper and Dellinger related recoveries of *E. coli* from teat apex swabs to infected quarters. Rendos, Eberhart and Kesler showed a relationship between bacterial populations in various bedding materials and teat apex bacterial populations and Bramley and Neave postulated that coliform populations in excess of one million per gram of wet bedding were associated with a high incidence of coliform mastitis. Jones showed *E. coli* to be more numerous in faeces from high yeilding cows than faeces from low yielders and Linton et al showed a positive correlation between serotyper of *E. coli* recovered from clinical mastitis cases and serotypes in the bovine intestinal tract. There is little published information on the influence of climatic conditions on bacterial bedding populations and thus indirectly upon teat apex contamination.

Materials and Methods

The study was carried out during 20 weeks of winter on a herd of 100 cows which was split into two groups relative to their milk yields, housed in cubicles (free stalls) and milked twice daily through a 10/10 low jar herringbone parlour. The average annual milk yield was 5,700 liters per cow.

The high yielding group occupied 51 cubicles in a concrete building with an asbestos roof which as well as cubicles possessed an integral feeding area and provided in total 40 cubic metres of air space per cow. The remainder of the group occupied 45 cubicles in a building of similar

construction but without a feeding area and offered 27 cubic metres of air space per cow.

Each cubicle had a concrete base with a slope of 37mm over its 2.1 metre length. A 50mm upstand was present at the rear to retain litter. The passageways were mechanically scraped once daily and litter was replenished twice weekly by the addition of 8kg of straw to each cubicle.

Thermocouples were placed in 3 cubicle beds in each house and connected to a Kent 6-channel recorder which printed continuous graphs of bedding temperatures on a moving paper roll. Each thermocouple was placed at the mid point of the cubicle width and 0.5 metres from the rear kerb beneath straw litter of average depth 60mm.

Instruments were installed at heights of 3 metres in both buildings to provide continuous records of the ambient temperature and humidity and the external environment was monitored at a local meterological station. The authors made weekly visits to check these records and collect samples according to the following schedule:

Cubicle Appearance

At the weekly visit each cubicle was given a condition score on a 0 to 9 scale, in which a score of 7 indicated a cubicle which veterinarians, advisors and farmers would consider as providing very good conditions of cleanliness and contamination of the bedding at the rear of the cubicle with faeces and moisture extending incrementally forwards from the kerb.

Bedding Samples

Samples of used bedding in approximately 100 gram amounts were taken from 3 cubicles in each house which had the mode score of the day. The cubicles possessing the thermocouple probes were also sampled similarly. Samples were collected from the area on which the udder of a recumbent cow would rest. The samples were stomached with sterile distilled water. Decimal dilutions were incubated at 37°C for 48 hours on (a) poured Yeastral Milk Agar to determine the total aerobic mesophilic bacteria and (b) in MacConkey broth to estimate coli-aerogenes by a 3-tube MPN technique. Positive coli-aerogenes samples were incubated at 44°C for 24 hours on Lactose Ricinoleate also employed to estimate *E. coli* populations in samples of freshly voided faeces collected during 4 of the visits.

Teat-apex Swabs

The hind teat apices of 10 cows selected at random from each of the 2 cow groups were swabbed before the udders were prepared for milking. Each swab, moistened in sterile Ringers solution, was twirled 6 times across the apex of the teat, then placed in sterile Ringers solution for transportation to the laboratory. The *E. coli* contaminations of the swabs were estimated by plating decimal dilutions of these Ringers solutions onto MacConkey agar and counting colonies after incubation to 24 to 48 hours at 44°C.

Milk Samples

After being swabbed, the same hind teat apices were cleaned with cotton-wool, soaked in 70% ethanol and 20ml milk samples were collected into sterile containers after discarding the strict fore-milk. These samples were cultured on 5% blood agar, Edward's medium and MacConkey agar and colonies counted. The cell counts of the samples were determined on a model ZF Coulter Counter. Samples of secretion from all quarters exhibiting signs of clinical mastitis were collected prior to antibiotic treatment and examined bacteriologically. Similar examinations were carried out on quarter samples from all cows which were dried off and which calved during the period of the study. Bulk milk samples were tested for their total bacterial count, *E. coli* content and cell count each month.

Milking Machine Condition

Plant rinsings and static machine tests were carried out monthly and dynamic machine tests were carried out weekly.

Results

Climate

The relative humidity both inside and outside the buildings averaged 90-95% throughout the study period. The temperatures inside the buildings fell for the first 12 weeks, then rose steadily during the remaining weeks as spring approached.

The outside temperature, and that of the larger cubicle house were about equal, whilst the temperature inside the small house was on average 2-4°C above the outside ambient. As outside temperatures rose towards the end of the study, temperature changes in the larger house lagged begind those outside.

The thermocouple recordings showed that the high yielding animals commonly raised bedding temperatures to around 30°C during lying periods of average length 2 hours, whilst the lower yielding animals in the smaller building raised bedding temperatures to a maximum of 25°C during the same lying times.

During the first half of January the mean temperature was 4°C below the previous months mean and cows in both groups remained lying down for periods which averaged 3 hours in length. During these periods, bedding temperatures of 26°C were recorded in beds occupied by low yielding cows and 35°C in beds used by high yielders.

Cubicle Bed Condition

An analysis of all appearace scores over the 20 weeks showed that the cubicles occupied by the high yielding cows had a greater proportion of higher appearance scores than those used by the low yield group as shown in table I.

Table I

APPEARANCE OF CUBICLES

Low Yield Group							
Score	3	4	5	6	7	8	9
Number	5	27	133	322	350	56	7
%	18.5			35.7		46.8	
High Yield Group							
Number	Nil	38	148	340	415	79	Nil
%		17.3		33.3		48.4	

Dry matter contents of the bedding samples from cubicles used by the high yielding cows were higher than those in samples from cubicles used by the low yield group, nevertheless *E. coli* populations were generally higher in samples from cubicles used by the high yielders when compared with samples from cubicles used by the low yielders. *E. coli* was the predominant organism in 93% of the 240 bedding samples examined, with *E. coli I* predominating in 60% of samples. Table II shows the wide variation in E. coli populations in bedding samples with the same appearance score and shows that *E. coli* bedding populations in excess of 10^6 per gram occurred nearly twice as frequently in cubicle bedding used by the high yield group as in bedding used by the low yield group.

Table II

BEDDING BACTERIA (E. COLI PER G.)

	10^2	10^3	10^4	10^5	10^6	10^7	10^8
Low Yield Group							
Number	2	14	32	31	14	3	-
%	50.0			32.3		17.7	
High Yield Group							
Number	Nil	8	15	41	26	5	1
%		24.0		42.7		33.3	

Teat Apex Bacterial Contamination

A week by week relationship between *E. coli* populations in bedding and the frequency with which this organism was recovered from teat apex swabs and hind quarter fore-milk samples was not found. However, positive teat apex swabs and hind quarter fore-milk samples were found in greater numbers from cows in the high yield house than those in the low yield house. Extrapolation of these culture results indicates that more than 25% of teats in the high teats being contaminated for 16% of the time in the low yield house. A similar situation existed with regard to fore-milk samples.

Quarter Infections

Fifty-five quarters showed clinical mastitis during the study period. Thirty-eight (69%) occurred in hind quarters and 17 (31%) in fore quarters. The culture results from these quarters are shown in table III.

Table III

Quarters Sampled	Organisms Cultured
30	E. Coli
6	Staphylococcus pyogenes
2	Streptococcus dysgalactine
2	Streptococcus uberis
15	No pathogens isolated
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55	
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Nearly half the clinical cases occurred during the first 40 days of lactation. Repeated clinical mastitis due to *E. coli* was seen in 4 quarters which between them accounted for 11 of the *E. coli* clinical episodes listed above, and during the random weekly sampling of fore-milks, 16 quarters were fortuitously sampled at varying intervals before they became clinical. Six of these quarters yielded *E. coli* on culture and had cell counts from 6 to 10 times higher than their fellow quarters at these samplings. The geometric rolling mean bulk milk cell count during the study was 328,000 cells per ml.

Hygiene Standards

Hygiene and function tests on the milking machine were satisfactory and bacteriological examinations of bulk milk samples gave plate count readings averaging 8,500 per ml, with *E. coli* not found in dilutions greater than 1ml.

Faeces Culture

Mean values of coliforms and *E. coli I* did not differ greatly between animals in the groups as shown in table IV.

Table IV

MEAN VALUES OF E. COLI IN FAECES

	Low Yield Cows	High Yield Cows
Coliforms At 37°C	9.3×10^6	1.7×10^7
E. coli I at 44°C	8.8×10^6	1.4×10^7

Discussion

During cold weather, greater temperature variations occurred in the high yield house than occurred in the low yield house. Some of this variation would have been due to the larger building having 11% more air space per cow than the smaller building, but cold air advection from adjacent hilly ground would also affect the temperature in the larger building to a greater degree than that in the smaller building.

The lack of correlation between *E. coli* bedding populations and *E. coli* mastitis cases on a week by week basis is partly explained by the wide variation in *E. coli* populations found in samples from cubicles with equal appearance scores. Additionally the small amount of evidence that a period of sub-clinical infection may preceed the clinical manifestations may account for some of this lack of correlation.

The cubicles used by the high yielders looked better and drier, yet samples yielded higher numbers of *E. coli* than those in the other building and representative teat swab and fore-milk cultures indicated that these bedding conditions were producing a high teat-end bacterial challenge. In this study there was no relationship between positive teat apex swab cultures and positive fore-milk cultures as demonstrated by Jasper and Dellinger.

The differences in E. coli contents of fresh faeces between the yield groups were not as marked in this study as that

carried out by Jones, nevertheless faeces from the high yielders did have a higher *E. coli* content and the volume of faeces produced by this group - probably due to the high plane of feeding - would probably have increased the accidental coliform innoculation of bedding.

The "incubation temperatures" produced during the lengthened periods of recumbency during cold weather could have encouraged the multiplication of the coliforms previously accidentally innoculated into bedding, as samples during these periods showed higher *E. coli* populations than preceeding or succeeding samples.

All E. coli mastitis cases occurred in the group of high yielders. This is not entirely unexpected as previous work has indicated that the cow's susceptibility is increased in early lactation, but feeding and husbandry practices at this period may super-impose an increased bacterial challenge.

This study casts doubt upon the usual visual assessments of the potential challenge which might accrue from cubicle bedding and indicates that climatic factors may, by influencing cow behaviour have an indirect influence on teat-end challenge. Adjacent topographical factors may be more important in the siting of buildings intended for housing milking cattle in winter than has been thought hitherto. Labour imputs should be directed primarily towards the maintenance of exemplary hygiene standards especially for cows in early lactation.

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For Your Library

Current information on the diagnosis, control, and prevention of bovine viral infections is presented concisely in *Viral Diseases of Cattle* just published by the Iowa State University Press.

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