Factors Associated with Mastitis in Ontario Dairy Herds: A Case Control Study

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ABSTRACT

Data from Ontario dairy cattle herds which had had a high average milk gel index for 1978 (cases) and from other herds which had had a low average during the same period (controls) were collected and analyzed using case control techniques. The purpose of the study was to contrast factors of husbandry and management between the two groups and to determine the relative contribution of each of these factors on mastitis (as determined indirectly by the milk gel index) at the herd level.

Control herds had higher average production levels than did case herds, shipping 1807 litres more milk per cow per year. Milk from control herds averaged 0.06 percentage points higher in butterfat, 0.19 percentage points higher in lactose and 0.05 percentage points lower in total protein. However, many factors can influence production, therefore these latter differences, in both shipped milk and composition, can not be attributed solely to differences in the prevalence of mastitis between the two groups.

Control herds were more likely to use teat dip, receive regular veterinary service, use dry cow antibiotic preparations and have knowledge concerning subclinical mastitis than were case herds. Control herds also tended to raise more of their own replacements, have a higher culling rate for reasons of low production and have a more modernized dairy operation. Case herds, on the other hand, were more likely to scrutinize foremilk, use more milking units per operator and wait longer between the start of stimulation and attachment of the milking unit.

The study confirms, under natural field conditions, the importance of integrated mastitis control practices and also reaffirms the relative importance of practices such as the use of teat dips and dry cow antibiotic preparations.

RÉSUMÉ

Cette étude consistait à colliger et à analyser à l'aide de techniques de contrôle des cas de mammite, des données relatives à des troupeaux laitiers expérimentaux ontariens qui, en 1978, avaient donné une moyenne élevée de l'indice de gel du lait ainsi qu'à des troupeaux témoins où cette moyenne s'était avérée plus basse. L'étude visait également à mettre en relief les facteurs de régie en usage dans ces deux groupes de troupeaux et à déterminer leur influence respective sur la mammite au sein d'un troupeau, comme l'indice de gel du lait aide indirectement à la préciser.

La production lactée annuelle moyenne des troupeaux témoins se révéla plus élevée que celle des troupeaux expérimentaux et elle atteignit 1 807 litres de plus par vache. Le lait de ces troupeaux contenait en moyenne 0,06% plus de gras, 0,19% plus de lactose et 0,05% moins de protéines totales. Plusieurs facteurs peuvent cependant influencer la production lactée; on ne peut par conséquent attribuer uniquement à la différence entre le nombre de cas de mammite de ces deux groupes de troupeaux, les différences quantitatives et qualitatives citées plus haut.

Les propriétaires des troupeaux témoins utilisaient plus régulièrement les bains de trayons, les services vétérinaires et l'antibiothérapie des vaches taries; ils

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connaissaient également mieux la mammite sous-clinique que les propriétaires des troupeaux expérimentaux. Ils élevaient aussi plus de sujets de remplacement, éliminaient plus de vaches faibles productrices et utilisaient un équipement plus moderne. Par ailleurs, les propriétaires des troupeaux expérimentaux avaient plus tendance à examiner les premiers jets de lait, à utiliser plus de trayeuses par opérateur et à attendre plus longtemps entre le début de la stimulation et la pose de la trayeuse.

Cette étude confirme l'importance de mesures intégrées pour le contrôle de la mammite, dans les conditions naturelles. Elle réaffirme aussi l'importance relative de pratiques telles que le bain de trayons et l'antibiothérapie des vaches taries.

INTRODUCTION

Bovine mastitis is an ecologically complex disease which can cause serious economic loss through lowered productive efficiency. In recent years, integrated mastitis control programs have been formulated and these programs have been demonstrated to be biologically effective and economically advantageous (3, 4, 5). Despite the development of these proven-to-be effective programs, mastitis, especially in its subclinical form, continues to exist in a great many herds at levels above that which are attainable. At the same time, however, many dairymen are successfully controlling the disease in their herds. The purpose of this study, therefore, was to contrast factors of husbandry and management between these two groups of producers and to determine the relative contribution of each of these factors on the prevalence of mastitis at the herd level in Ontario. The variable which was used to distinguish between the two groups of producers was the milk gel index (MGI).

The MGI is an objective screening test for the detection of abnormal milk and is based on the principle of the thickening of protein found in nucleated somatic cells. The test, as applied in Ontario by the Ontario Ministry of Health, is performed monthly on each producer's bulk tank milk and is reported in MGI units which can range from zero to 100. The correlation between the MGI and the somatic cell count per mL is relatively low; however, to facilitate understanding the relationship between the two can be exemplified approximately as follows: 0 – less than 200,000, 20 – 700,000 and 40 – 1,200,000.

MATERIALS AND METHODS

The mean of the 12 monthly milk gel indices (MGIMEAN) for 1978 was calculated for all licenced Ontario milk producers. The 550 producers with the highest MGIMEAN were selected and were defined to constitute the case group. Six of these producers resided outside the province and were subsequently removed from the study, leaving a total of 544. For each case producer, a control producer was selected and was defined to be the producer with the lowest MGIMEAN residing in the same county. If more than one control producer was possible, the one with the producer licence number which was closest numerically to that of the case was chosen.

Data for the study were obtained via a structured questionnaire, and from the records of the Ontario Milk Marketing Board (OMMB) and the Dairy Herd Improvement Association (DHIA).

The questionnaire was used to collect data regarding each producer's husbandry management practices, including the level of adoption of mastitis control procedures and his perception of clinical and subclinical mastitis.

After pretesting and modifications had been made to the questionnaire, it was mailed along with an introductory letter and a stamped self-addressed envelope to all case and control producers. Ten days following the first mailing, a reminder letter was sent to those producers who had not yet responded. Fourteen days after the reminder letter, a second copy of the questionnaire along with a covering letter and stamped self-addressed envelope was sent to all nonrespondents. Questionnaires which were received later than 90 days following the initial mailing were arbitrarily not included in the analysis phase of the study.

Questions which were unanswered were handled in one of two ways. If the variable was continuous the missing value was replaced by the group mean. If the variable was measured qualitatively the group mode was used.

A data file was created and consisted of the following OMMB production data for 1978 for each herd: total milk shipped during the year (TOTMILK, litres) and average percent butterfat, protein and lactose (AVBF, AVPRT AVLACT). Average shipped milk per cow per year (AVEMILK, litres) was then estimated by dividing the quantity TOTMIK by the average number of cows which were milked during the year. Data derived via the questionnaire were added to the record for each respondent. For those respondents who were members of the DHIA during 1978 was added the percent days in milk for their herd (DIM), herd average milk production (MILKKG, kg), herd average fat production (FATKG, kg), average percent fat (PERFAT), breed class average for milk (BCM) and breed class average for fat (BCF).

The chi square test was used to determine the statistical association between husbandry management factors and case or control status. Those variables for which a statistical association was found ($p \leq 0.05$) are listed, along with their description and coding, in Table I. Stepwise discriminant analysis was used to identify, from among the variables listed in Table I, those variables which were best able to differentiate between the two groups of producers. The Student t-test was used to compare the two groups with respect to production data.

RESULTS

The overall response rate to the questionnaire was 65.2%. The response rate for the case and control groups was 49.4 and 80.9% respectively.

The case and control groups are compared with respect to production data in Table II. Of the case and control respondents, 34 and 151 respectively were members of the DHIA and hence had values for DIM, MILKKG, FATKG, PERFAT, BCM and BCF.

The two groups were statistically significantly different ($p \leq 0.01$) for all production-related variables except DIM, with mean values for the control group being higher than the cases for all variables except MGIMEAN, AVPRT and PERFAT. Control herds averaged 1807 litres more shipped milk per cow per year than case herds. Milk from control herds averaged 0.06 percentage points higher in butterfat, 0.19 percentage points higher in lactose and 0.05 percentage points lower in total protein. With respect to herds on

TABLE I. Variables Associated[a] with Group Status in a Case Control Study of Mastitis in Ontario, 1978

Variable	Description and Codes
TEATDIP	Teat dip. Yes = 1; No = 0.
VETVISITS	Monthly or bimonthly veterinary visits. Yes = 1; No = 0.
REPLACE	Source of majority of herd replacements. Home-raised = 1; Purchased = 0.
DRYCOW	Dry cow treat all cows. Yes = 1; No = 0.
CHKMILK	Routinely examine foremilk. Yes = 1; No = 0.
KNOWDEF	Understand the meaning of the term subclinical mastitis. Yes = 1; No = 0.
MANSYSTEM	Mechanized manure handling system. Yes = 1; No = 0.
MILKSYST	Milking system. Milking parlor = 1; High line pipeline = 2; Low line pipeline = 3; Bucket milker = 4; Step-saver = 5.
HOUSYSTEM	Housing system. Loose housing = 1; Free stall = 2; Tie stall = 3; Other =4.
CULLRATE	Culling rate for reason of low production.
UNITOPER	Milking units used per operator.
HERDSIZE	Average number of cows milking during 1978.
OPERATION	Years operating the farm. 0–5 = 1; 6–10 = 2; 11–15 = 3; 16–20 – 4; 21–25 = 5; 26–30 = 6; greater than 31 = 7.
MAINACT	Principal farming activity. Dairy = 1; Other = 0.
FEDSYSTEM	Mechanized feeding system. Mechanized = 2; Partial = 1; None = 0.
FEDAFT	Bulk of ration fed after milking. Yes = 1; No = 0.
INFLATE	Number of cow milkings per set of inflations. 0–250 = 1; 251–500 = 2; 501–750 = 3; 751–1000 = 4; 1001–1250 = 5; 1251–1500 = 6; 1501–2000 = 7; Over 2000 = 8.
TOTWASH	Prepare udder using single service paper towel. Yes = 1; No = 0.
STRIP	Routinely machine strip. Yes = 1; No = 2; Don't know =3.
TIMTO	Upper limit of interval between start of stimulation and commencement of milking (minutes). 0.5 = 1; 1 = 2; 1.5 = 3; 2 = 4; 2.5 = 5; 3 = 6; Over 3 = 7.
RECORD	Record lactation mastitis treatments. Yes = 1; No = 0.

[a]$p \leqslant 0.05$

TABLE II. Mean and Comparison of Production Variables in a Case Control Study of Mastitis in Ontario, 1978

Variable[a]	Case[b] Producers	Control[b] Producers
MGIMEAN	35.1 ± 5.4[c]	0.6 ± 1.4
AVEMILK (L)	4288 ± 1177	6095 ± 1157
AVBF (%)	3.70 ± 0.33	3.76 ± 0.22
AVPRT (%)	3.23 ± 0.21	3.18 ± 0.14
AVLACT (%)	4.83 ± 0.16	5.02 ± 0.14
DIM (%)	82.9 ± 4.9	83.1 ± 7.5
MILKKG (kg)	4863 ± 969	6158 ± 780
FATKG (kg)	184 ± 36	226 ± 29
PERFAT (%)	3.80 ± 0.37	3.68 ± 0.20
BCM	100 ± 30	123 ± 25
BCF	98 ± 30	120 ± 25

[a]See text for explanation
[b]N = 544 for all variables except DIM to BCF inclusive where N = 34 and 151 for case and control producers respectively
[c]Mean ± SD, all variables except DIM statistically significantly different ($p \leqslant 0.01$)

the DHIA program, the control group averaged 1295 kg more milk and 42 kg more total butterfat per cow per year. Milk from control herds averaged 0.12 percentage points less butterfat and were higher by 23 and 22 BCM and BCF points respectively.

The results of the discriminant analysis are presented in Table III. The variables, including the means for each of the case and control groups, and the standardized discriminant function coefficients, are listed by order of entry into the discriminant function. Of the variables entered into the discriminant analysis (Table I), only the variables MAINACT and FEDAFT were excluded from the discriminant function by the final iteration of the stepwise procedure.

Control herds, in comparison to case herds (Table III), were more likely to use teat dips (TEATDIP), have regular veterinary service (VETVISITS), raise more of their own replacements (REPLACE), have a higher culling rate for reason of low production (CULLRATE), not check foremilk (CHKMILK), use dry cow antibiotic preparations (DRYCOW), use fewer milking units per operator (UNITOPER) and use a housing system where cows are tied (HOUSYSTEM). Control producers were also more likely to have a more modernized dairy operation, as revealed by the variables MANSYSTEM, MILKSYST and FEDSYSTEM, have knowledge concerning subclinical mastitis (KNOWDEF) and attach the milking unit earlier, after the start of stimulation, (TIMTO) than case herds.

TABLE III. Mean of Variables and Result of Discriminant Analysis in a Case Control Study of Mastitis in Ontario, 1978

Variable[a]	Case Producers (N = 269)	Control Producers (N = 440)	Standardized Discriminant Coefficient
TEATDIP	0.35 ± 0.48[b]	0.85 ± 0.35	−0.52
VETVISITS	0.12 ± 0.32	0.42 ± 0.49	−0.22
REPLACE	0.83 ± 0.38	0.97 ± 0.18	−0.19
CULLRATE	0.10 ± 0.05	0.13 ± 0.08	−0.18
CHKMILK	0.64 ± 0.48	0.46 ± 0.50	0.20
DRYCOW	0.26 ± 0.44	0.56 ± 0.50	−0.15
UNITOPER	2.55 ± 0.94	2.34 ± 0.86	0.20
MANSYSTEM	0.73 ± 0.45	0.90 ± 0.31	−0.10
MILKSYST	3.24 ± 1.32	2.75 ± 1.22	0.20
HOUSYSTEM	2.87 ± 0.45	2.94 ± 0.32	−0.15
KNOWDEF	0.44 ± 0.50	0.70 ± 0.46	−0.10
HERDSIZE	32.35 ± 18.63	33.06 ± 13.97	0.15
TIMTO	3.78 ± 1.97	3.05 ± 1.52	0.10
FEDSYSTEM	0.52 ± 0.62	0.70 ± 0.57	−0.09
TOTWASH	0.26 ± 0.44	0.50 ± 0.50	−0.07
OPERATION	4.47 ± 2.03	4.03 ± 1.95	0.08
INFLATE	6.25 ± 2.33	6.11 ± 2.13	−0.06
RECORD	0.30 ± 0.45	0.42 ± 0.49	0.05
STRIP	1.60 ± 0.71	1.44 ± 0.63	0.05
Discriminant Function Group Centroid	0.85	−0.52	
Percent Herds Correctly Classified by Discriminant Function	78.4	82.3	

[a]See Table I for definitions and codes, variables listed in order of entry into discriminant function
[b]Mean ± SD

The variables TOTWASH, OPERATION, INFLATE, RECORD and STRIP (Table I) did not by themselves significantly add to the discriminant function and will not be discussed further.

The group centroids were 0.85 and −0.52 for case and control producers respectively.

The discriminant function correctly classified 78.4% of the case herds and 82.3% of the controls, for an overall correct classification of 80.8%.

DISCUSSION

In this retrospective study, the average monthly MGI for the year 1978 was used as a means for selecting herds with a high (cases) and low (controls) prevalence of mastitis. While it has been reported (6, 9) that the correlation between bulk tank milk somatic cell counts and percent quarters infected is only of thhe order of 0.50, the assumption was made by the authors that the use of average monthly MGI's and the selection of opposite extremes for the case and control groups resulted in the two groups having very different levels of udder infection.

The response rate for the questionnaire was dissimilar between the case and control groups and was 49.4 and 80.9% respectively. However, the mean MGIMEAN for those case producers who returned the questionnaire was 35.1 while the mean MGIMEAN for all case producers regardless of whether they returned to questionnaire or not was 35.5. This would indicate that while only approximately half the case producers responded they were representative.

Control herds had higher average production levels than did case herds, averaging 1807 litres more shipped milk per cow per year (Table II). However, many factors other than mastitis can influence production. Hence, while some of the increase may be associated with a reduced level of mastitis, the remainder may be explained, for example, by possible nutritional, genetic and other differences between the two groups.

The finding that the average percent protein for shipped milk (AVPRT) was higher for the case group than for the control group (Table II) is of interest. A number of reports have indicated (2, 7) that total protein levels remain relatively constant, regardless of somatic cell counts, although Ashworth *et al* (1) reported a small increase in total protein in mastitic quarters compared to nonmastitic ones. However, the ratio of casein to total protein is lower in high cell count milk (2).

The average percent butterfat of shipped milk (AVBF, OMMB) for the control group was significantly higher ($p \leqslant 0.01$) than the case group. However, the reverse was found when the average percent fat (PERFAT, DHI herds only) was considered. The apparent discrepancy could be due to a number of factors including the fact that OMMB fat determinations are done on bulk tank milk in contrast to the DHI where determinations are made on individual cow samples and the dissimilarity between the number of case and control producers with DHI records (34 versus 151).

The need to adopt an integrated approach to mastitis control has been recognized and recommendations have been made in this regard for a number of years. Generally included in the recommendations are the need for: regular assessment and upgrading of milking equipment, the use of a teat dip and dry cow antibiotic preparation, the culling of chronically mastitic cows and the practice of treating all clinical cases of mastitis promptly and completely. It was impossible to assess, with any degree of accuracy by means of a questionnaire, the degree to which the first and last of the above recommendations may have been implemented by a producer. It was possible, however, to assess whether or not teat dip or dry cow antibiotic preparations were used. The authors attempted to assess the culling practice of each producer with regard to chronically mastitic cows by first determining the number of cows in each herd which the producer culled for reasons of mastitis or low production. A culling rate for each of the latter was calculated and the association with case or control status investigated. No association ($p \gtrsim 0.05$) was detected between culling rate for mastitis and study status; however, there was a statistical association with culling for low production ($p \leqslant 0.05$). This is not surprising as most cows with chronic mastitis would be subclinical and because cows with subclinical mastitis produce less milk, the producer may attribute culling of these animals to low production. The authors used this latter rate, i.e. culling rate for low production (CULLRATE), as an approximation of the rate at which a producer would cull chronically mastitic cows from his herd.

The three mastitis control recommendations that were assessed either directly or indirectly by means of the questionnaire, i.e. the use of teat dips (TEATDIP), culling chronically mastitic cows (CULLRATE) and the use of dry cow antibiotic preparations (DRYCOW), entered into the discriminant function respectively on step one, four and six (Table III).

On the basis of the absolute magnitude of the discriminant coefficients, the variable which was best able to discriminate between the case and control groups was TEATDIP (Table III). This is not surprising as its effectiveness in mastitis control is well documented. For example, Wesen and Shultz (8) reported a 53.2% reduction in new quarter infections and a 24% reduction in clinical treatments required in teat dipped quarters compared to controls. In addition he found that the prevalence of subclinically infected quarters dropped from 32% to 23% in teat dipped quarters and rose from 27% to 30% in undipped quarters during the same 13 month period. The results of the present study confirm the effectiveness of the use of teat dip under natural field conditions.

Other variables that entered into the discriminant function early were VETVISITS REPLACE and CHKMILK (Table III).

Producers who reported either regular monthly or bimonthly veterinary visits (VETVISITS) were more likely to be in the control group. This may be a direct effect of veterinary care or reflect the overall more progressive attitude of control producers.

Ninety-seven percent of control producers raised the majority of their herd replacements (REPLACE) compared to 83% for case producers.

Case producers were more likely to check foremilk (CHKMILK) before attaching the milking machine than were control producers (64 vs 46%). This could imply that producers with a high prevalence of mastitis are more likely to check foremilk because they realize they have a mastitis problem in their herd or that checking foremilk *per se* directly influences mastitis levels. Further studies would be necessary to clarify this point.

Case producers utilized an average of 2.55 milking units per operator (UNITOPER) compared to control producers who used an average of 2.34 (Table III). This, combined with the fact that case producers waited longer than control producers between the start of stimulation and attachment of the milking unit (TIMTO) would tend to indicate that case producers attempted to use more milking units than they could effectively manage.

Seventy percent of the control producers stated they were familiar with and had some knowledge of subclinical mastitis (KNOWDEF) compared to 44% for the case group. While knowledge of subclinical mastitis does not necessarily imply the producer will implement and maintain mastitis control practices, the reverse is probably true. That is, if a producer is not aware that he has a problem he is not likely to do something about it and this is reflected by the low percentage of case producers who used, for example, teat dips or dry cow antibiotic preparations.

Control producers were more likely to have mechanized manure handling (MANSYSTEM) and feeding systems (FEDSYSTEM) than were case producers and were more likely to have milking parlours or pipeline milking systems (MILKSYST) (Table III). This suggests that control producers in general had more modernized dairy operations than did case producers.

This study confirms, under natural field conditions, the importance of integrated mastitis control programs. It also reaffirms the relative importance of procedures such as the use of teat dips and dry cow preparations.

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