Effects of Clinical Mastitis on Milk Yield in Dairy Cows

P. J. RAJALA-SCHULTZ,*,† Y. T. GRÖHN,*
C. E. McCULLOCH,‡ and C. L. GUARD*
*Department of Population Medicine and Diagnostic Sciences,
College of Veterinary Medicine,
Cornell University, Ithaca, NY 14853
†Department of Clinical Veterinary Sciences,
Faculty of Veterinary Medicine, PO Box 57,
FIN-00014 Helsinki University, Finland
‡Department of Statistics,
Cornell University, Ithaca, NY 14853

ABSTRACT

The effect of clinical mastitis on milk yield was studied in 24,276 Finnish Ayrshire cows that calved in 1993 and were followed for one lactation (i.e., until culling or the next calving). Cows that had only mastitis, but no other diseases, and cows that had no diseases (healthy cows) during the lactation were included in the study. Monthly test day milk yields were treated as repeated measurements within an animal in a mixed model analysis. Mastitis index categories were created to relate the timing of mastitis to the test day milk measures. Statistical models (a separate model for each parity) included fixed effects of calving season, stage of lactation, and mastitis index. An autoregressive correlation structure was used to model the association among the repeated measurements. The effect of mastitis occurring at different periods during the lactation was studied. The daily loss during the first 2 wk after the occurrence of mastitis varied from 1.0 to 2.5 kg, and the total loss over the entire lactation varied from 110 to 552 kg and depended on parity and the time of mastitis occurrence. Regardless of the time of occurrence during the lactation, mastitis had a long-lasting effect on milk yield; cows with mastitis did not reach their premastitis milk yields during the remainder of the lactation after onset of the disease.
(**Key words**: mastitis, milk yield, repeated measures, mixed model)

Abbreviation key: **LIR** = Lactational incidence risk.

INTRODUCTION

Mastitis is one of the most common dairy cow diseases (3, 5, 9, 17, 20), and it can cause considerable losses to dairy farmers. The losses accrue from several sources (19), one of which is decreased milk yield. Several studies have found that clinical mastitis has a detrimental effect on milk yield (1, 6, 12, 16). Subclinical mastitis or high SCC has also been associated with decreased milk yield (8, 10). The carry-over effect of mastitis and high SCC from one lactation to the next has been found to be, in general, statistically significant but small (10); only if the cow had three or more infected quarters was her yield affected in the next lactation (12). The effect of clinical mastitis can differ depending at which stage of lactation the disease occurs (15). Results showing a beneficial effect of clinical diseases of the udder on milk yield have also been reported (8); in that study, the effect was attributed to the therapy provided to the cows affected with the condition.

A general problem with previous research on the effect of diseases on milk yield is that the focus has been on the entire 305-d lactation curve. The 305-d milk yield cannot capture short-term fluctuations and drops in milk yield. Cows with mastitis are often higher yielding cows, and they yield more milk, even having contracted the disease, than do their healthy and generally lower yielding herdmates (11). Erroneous conclusions are possible, using a summary measure such as 305-d milk yield, due to faulty assumptions and choice of inadequate statistical methods. More recently, approaches considering monthly or daily milk measurements have been advocated.

The purpose of this study was to estimate the effect of clinical mastitis on milk yield in Finnish Ayrshire cows using monthly test day milk yields.

MATERIALS AND METHODS

Data

The data for this study were from 24,276 Finnish Ayrshire dairy cows that calved during 1993 and were

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followed until the next calving or culling. The cows were in herds that belonged to the milk registry and the national dairy cow health recording system. These data are a subset of a larger study population of 39,727 Finnish Ayrshire cows, which have been described in detail previously (17). Cows that had no diseases and cows that had only mastitis but no other diseases during the study lactation were included in the current study.

Finnish farmers do not have access to veterinary drugs without supervision of a veterinarian, so virtually all diseases are diagnosed and treated by a veterinarian during farm visits. Veterinary diagnoses of clinical mastitis were used for this study. Diagnoses were made according to ordinary clinical methods under normal field conditions. Disease occurrence was expressed as lactational incidence risk (**LIR**), which was calculated by dividing the number of cows with at least one episode of mastitis by the total number of cows at risk and multiplied by 100 (as it was presented as a percentage). Only the first occurrence of mastitis was considered in this study; later cases of mastitis were ignored. Calving dates, disease dates, and dates for monthly test day milk sampling were available.

Monthly test day milk yields, taken at approximately 30-d intervals, were used to study the effect of mastitis on milk yield. The lactation was divided into 17 stages: milk records taken within 60 d after calving were grouped by 10-d intervals, records from 61 to 180 d were grouped into 20-d intervals, and records taken later than 180 d were grouped into 30-d intervals. Only test day milk yields until 330 d after calving were considered.

Parity had four levels: 1, 2, 3, and 4 or higher. Four calving seasons were defined by 3-mo intervals: winter, December to February; spring, March to May; summer, June to August; and fall, September to November.

Statistical Analysis

In these data, repeated measurements were present in both space and time. Cows within the same herd were clustered in space, and repeated measurements of daily milk yields of the same cow were correlated in time. Repeated measures data analysis is distinguished from simple linear models by the covariance structure of the observed data. In a typical repeated measures experiment, two measurements taken at adjacent times are more highly correlated than two measurements taken several time points apart (14).

One type of statistical analysis that can be used for repeated measures is based on the mixed model with a special parametric structure for the covariance matrices. This type of methodology has been computationally feasible only in recent years. It is applied in PROC MIXED in SAS (14), typically using the REPEATED statement. This procedure was used for these data with the monthly test day milk yields as the outcome variable. A cow will usually have approximately 10 monthly test day milk yields recorded during a lactation. Because milk yield measurements from the same lactation for a cow are correlated, it is important to account for this correlation in estimating the effects of disease on milk yield.

In our previous study (18), we compared three commonly used correlation structures (simple, compound symmetry, and first-order autoregressive) and found the first-order autoregressive correlation structure to provide the best fit to these data.

In PROC MIXED, the standard linear model is generalized to form a mixed model: $\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\boldsymbol{\gamma} + \boldsymbol{\epsilon}$ with $\mathrm{Var}(\boldsymbol{\gamma}) = \mathbf{G}$ and $\mathrm{Var}(\boldsymbol{\epsilon}) = \mathbf{R}$ so that $\mathrm{Var}(\mathbf{y}) = \mathrm{ZGZ}' + \mathrm{R}$, where $\mathbf{y}$ = vector of test day milk yields, $\boldsymbol{\beta}$ = vector of fixed effects, $\boldsymbol{\gamma}$ = random herd effects, and $\boldsymbol{\epsilon}$ = vector of random errors (with random variation, σ^2).

A correlation pattern can be modeled in PROC MIXED in two ways, either by introducing a correlation pattern in the random effects, $\boldsymbol{\gamma}$ through a nonidentity matrix **G**, or by an **R** matrix so that it equals σ^2 multiplied by some nonidentity matrix.

The effects of mastitis on test day milk yields were studied separately for each parity (i.e., parities 1, 2, 3, and 4 or higher). Calving season, stage of lactation, and disease variables were fixed effects in each model.

Analysis 1. In this analysis, the yield of healthy cows was used for comparison. To differentiate between cows with and without mastitis, a disease index variable was created for each test day milk yield to study the effects of mastitis on milk yield.

The mastitis index variable was defined as follows: 1 = test day milk yields collected more than 28 d before the diagnosis, 2 = test day yields collected between 15 and 28 d before the diagnosis, 3 = test day milk yields collected within 14 d before the diagnosis, 4 = test day yields collected within 14 d after the diagnosis, 5 = test day yields collected between 15 and 28 d after the diagnosis, 6 = test day yields collected between 29 and 42 d after the diagnosis, 7 = test day yields collected later than 42 d after the diagnosis, and 8 = the cow had not been diagnosed with mastitis (i.e., the milk yield of the healthy cows was considered the reference).

TABLE 1. Lactational incidence risks[1] (LIR; percentage) of clinical mastitis by parity of Finnish Ayrshire cows.

	Parity				
	1	2	3	4+	Overall
Entire data set[2]	14.2	16.5	17.6	20.2	17.0
Mastitis data set[3]	12.1	14.3	14.9	15.9	14.0

[1](Number of cows with mastitis/number of cows at risk) × 100%.

[2]Finnish Ayrhsire cows (39,727) that calved in 1993 and were followed for one lactation.

[3]A subset of the entire data set; includes only cows that had no diseases and cows that had mastitis but no other diseases during the lactation (24,274 cows).

Analysis 2. In these analyses, the milk yield of the mastitic cows more than 4 wk prior to the clinical onset and diagnosis of the disease was used as the reference. To study whether mastitis had a different effect and depended on the stage of lactation during which it occurs, three periods for mastitis occurrence were considered: 1) before the peak yield (period 1); 2) between the peak and 120 d after calving (period 2); or 3) later than 120 d after calving (period 3). A separate analysis was run for each parity in each period. The peak for each parity was calculated using Wood's equation $y_t = at^b e^{-ct}$ (21), where y_t = test day milk yield on day t, and the peak occurs (b/c) days after calving.

For period 1, the mastitis index was defined as in analysis 1 except for the following differences: 1 = the cow was healthy (i.e., had not been diagnosed with mastitis), 2 = test day yields collected between 7 and 14 d before the diagnosis (i.e., 1-wk period), 3 = test day milk yields collected within 7 d before the diagnosis (i.e., 1-wk period), and 8 = test day milk yields collected more than 28 d before the mastitis diagnosis from cows that had mastitis after the peak (reference level).

For periods 2 and 3, the mastitis index was defined as in analysis 1 with the following changes: 1 = the cow was healthy (i.e., had not been diagnosed with mastitis), and 8 = test day milk yields collected more than 28 d before the diagnosis (reference level).

Analysis with herd as random effect. In the previous analyses, we did not separate herd and cow effects. To determine whether random herd in the model would change the estimates, an analysis was run and accounted for the herd effect in the G matrix. However, because of the large number of herds in the data set (over 2300 herds) and, thus, enormous space and memory requirements, we were not able to use the entire data for the analysis. Therefore, 25% of the herds in the data were randomly selected, and the analysis was run with herd as a random effect using the data from parity 3 cows, mastitis occurring before peak, and milk yield of cows with mastitis (analysis 2) as the reference level. We repeated the analysis 10 times and compared the mean of these results with the original results.

RESULTS AND DISCUSSION

Table 1 presents the LIR for acute mastitis by parity for these data (i.e., healthy cows and cows with only mastitis, later also referred to as the mastitis data) and for the entire data set from which this subset of data originated (17). The overall LIR for mastitis in the mastitis data was 14.0 %; in parities 1, 2, 3, and 4 or higher it was 12.1, 14.3, 14.9, and 15.9%, respectively. In the entire data set, the corresponding LIR were 17.0, 14.2, 16.5, 17.6, and 20.2, which shows that the LIR were lower in the mastitis data, suggesting that cows often have other diseases besides mastitis during lactation. This phenomenon seems to hold true, especially for older cows. The median time of the first mastitis occurrence in these data was 44 d after calving; however, 25% of the cows had mastitis within the first 4 d after parturition. The distribution of cases of mastitis during a lactation is presented in Figure 1.

We restricted our analysis to cows that had no diseases at all (referred to as healthy cows) and to cows that had only mastitis but no other diseases during the study lactation. Therefore, we were able to ensure that the estimates for the mastitis effect on milk yield were not confounded by any other diseases, but that the effect could truly be attributed to mastitis only.

The peak of the yield in these data for parity 1 cows occurred on d 58, for parity 2 cows on d 39, and for cows in parity 3 and 4 or higher, the peak occurred on d 40.

Analysis 1

The results from analysis 1, which compared the milk yield of cows with mastitis with that of healthy cows, clearly indicated that before contracting the

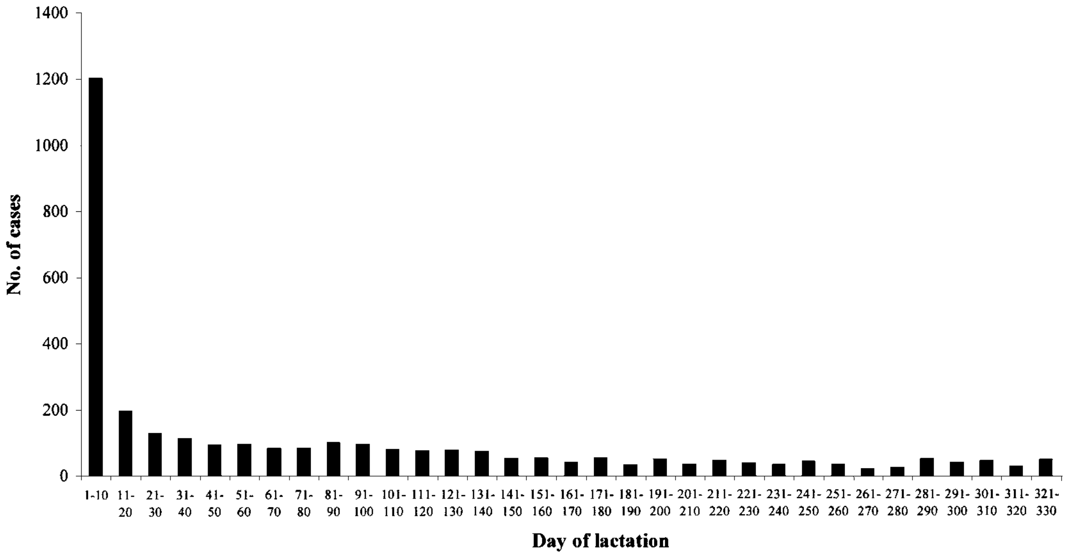

Figure 1. The distribution of cases of mastitis during a lactation.

disease, cows with mastitis yielded more milk than did healthy cows (Figures 2 and 3). The bars in Figure 2 represent differences in daily milk yields between cows with mastitis and healthy cows. A 0 value indicates equal yield among healthy cows and cows with mastitis; positive values indicate that cows with mastitis yielded more than did healthy cows. Milk yield began to decline 4 wk before the clinical onset of mastitis in all parities and dropped below the yield of the healthy cows during the first 2 wk after the diagnosis. Yield started to increase after this period, but it did not reach the level it was at more than 4 wk before the onset of mastitis during the rest of the lactation (Figure 2).

Figure 3 shows the lactation curves of healthy cows and cows with mastitis in parity 2. The lactation curves in all the other parities followed the same pattern. It is apparent from the figure that cows with mastitis yielded more than did their healthy counterparts despite disease. This result is in accordance with our previous study (17), which showed that increased milk yield was a risk for mastitis in Finnish Ayrshire cows. Other studies have also reported increased mastitis risk with increased milk yield (2, 11).

Mastitis clearly affected the milk yield, but the difference between the milk yield of the healthy cows and the mastitic cows after mastitis was not statistically significant; mastitis merely lowered the yield of the cows that contracted the disease to the same level as that of the healthy cows. Thus, these results suggested that comparison of the yield of mastitic cows with that of the healthy cows was not the most appropriate approach to the problem of estimating the effect of mastitis on milk yield. One needs to calculate the loss indirectly from the premastitis yield, otherwise the true effect of mastitis would be drastically underestimated. Therefore, the yield of cows with

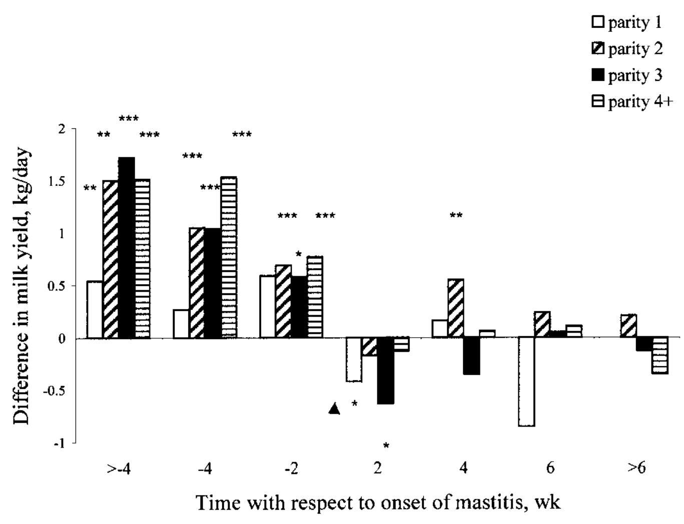

Figure 2. Effect of mastitis on milk yield (kilograms). Bars represent the daily milk yields of cows with mastitis. The milk yield of healthy cows was subtracted for reference. Positive values indicate that cows that had mastitis had greater yields than did healthy cows. A 0 value indicates equal yield among healthy cows and cows with mastitis. The arrow shows the time of onset of mastitis. Statistical significance of the differences in milk yield between healthy cows and cows with mastitis is shown in the figure: $*P \le 0.05$, $**P \le 0.01$, $***P \le 0.001$.

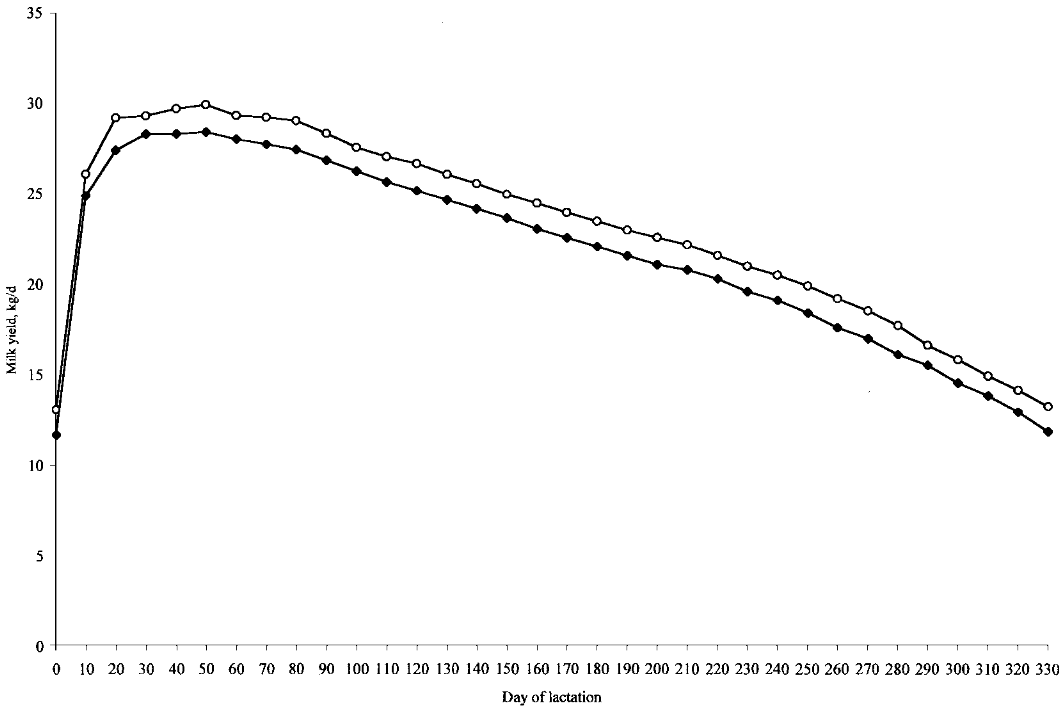

Figure 3. Lactation curves of healthy cows (♦) and cows with mastitis (o) in parity 2.

mastitis prior to onset of mastitis was chosen as the reference point for further analyses on modeling the effect of mastitis on milk yield.

Analysis 2

Tables 2 to 4 present the results from analysis 2 with each table presenting results for one of the lactation periods. In these analyses, the milk yield of cows with mastitis more than 4 wk prior to the clinical onset of the disease was used as the reference category.

When mastitis occurred during early lactation (before the peak), the daily losses during the first 2 wk after the clinical onset of the disease varied from 1.1 to 2.5 kg and depended on parity (Table 2). Yield never reached the premastitis level for the rest of the lactation in any parity. The total loss caused by mastitis during the lactation varied between 294 and 552 kg (the total loss was calculated assuming a 305-d lactation and mastitis occurring on d 7). The amount of milk loss increased with increasing parity and indicated that higher yielding, older cows had greater losses. The loss among parity 1 cows was 4.6% of the overall lactational 305-d yield; in parities 2, 3, and 4 or higher it was 4.1, 6.9, and 7.4%, respectively.

The problem in estimating the effect of mastitis in the early stage of lactation on milk yield was that a large proportion of the cows had mastitis so early that they did not have any milk measures taken before the onset of disease (Figure 1). Therefore, we used the premastitis (more than 4 wk before the onset) milk yield of those cows that contracted mastitis later during the lactation as the reference. If cows contracting mastitis later in the lactation were not as high yielding cows as those contracting the disease early in lactation, underestimation of milk loss during the early lactation would result.

When mastitis occurred between peak and 120 d, the daily losses within the first 2 wk after the diagnosis of mastitis varied between 1.3 and 2.1 kg (Table 3). There was no significant effect of milk reduction due to mastitis prior to the clinical onset of disease. The overall losses caused by mastitis occurring between peak and 120 d varied between 300 and 352 kg (the loss was calculated assuming a 305-d lactation and mastitis occurring on d 90). The youngest cows (parity 1) seemed to be affected most severely (proportionally) by mastitis occurring in this period. Cows with mastitis never reached their premastitis yield but remained at a significantly lower level for the rest of the lactation in all parities.

When mastitis occurred during late lactation, the effect of milk reduction was apparent 2 to 4 wk prior to the clinical disease and suggested the presence of subclinical mastitis (Table 4). This result is in agree-

TABLE 2. Effect of the occurrence of mastitis before the peak yield on milk yield (kilograms) of 24,276 Finnish Ayrshire cows that calved in 1993 and were followed for one lactation.[1]

	Parity							
	1		2		3		4+	
Effect[2]	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
14–8 d BD	–1.5*	0.5	–1.0	1.0	–0.1	1.2	–1.9	1.0
7–1 d BD	–1.0	0.6	–0.8	0.7	–2.4**	0.9	–2.2**	0.7
0–14 d AD	–1.7***	0.3	–1.1**	0.4	–2.5***	0.5	–1.8***	0.5
15–28 d AD	–1.2***	0.3	–0.7	0.4	–2.3***	0.5	–2.0***	0.4
29–42 d AD	–0.9***	0.3	–0.9*	0.4	–1.1**	0.5	–1.6***	0.4
>42 d AD	–0.9***	0.2	–1.0***	0.3	–1.6***	0.4	–1.8***	0.3
Healthy cow	–0.9***	0.2	–1.3***	0.2	–1.6***	0.3	–1.6***	0.3
Total loss[3]	–294.1	4.7%[4]	–284.0	4.1%[4]	–509.0	6.9%[4]	–551.8	7.4%[4]

[1]The reference level is the milk yield prior to the onset of mastitis in cows that contracted mastitis after the peak. Season of calving and stage of lactation were included in each model as fixed effects.

[2]Period when the test day milk sample was collected with respect to the diagnosis of clinical mastitis. BD = before diagnosis, and AD = after diagnosis.

[3]The total loss was calculated assuming a 305-d lactation and the occurrence of mastitis on d 7 after calving.

[4]Percentage loss, calculated from the overall yield of a 305-d lactation.

*$P \leq 0.05$.

**$P \leq 0.01$.

***$P \leq 0.001$.

ment with those of Delyuker et al. (7), Dohoo and Martin (8), and Fetrow et al. (10); they showed that subclinical mastitis was associated with decreased milk yield. The cows never totally recovered from the disease but yielded between 0.7 to 2.5 kg/d less milk (depending on parity) for the rest of the lactation than they would have without mastitis. The overall losses during the lactation varied between 110 and 387 kg and depended on parity.

Lucey and Rowlands (15) reported that mastitis can have a different effect depending on the stage of lactation in which it occurs. They found the reduction

TABLE 3. Effect of the occurrence of mastitis between the peak and d 120 on milk yield (kilograms) of 24,276 Finnish Ayrshire cows that calved in 1993 and were followed for one lactation.[1]

	Parity							
	1		2		3		4+	
Effect[2]	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
28–15 d BD	–0.8*	0.4	–0.3	0.4	–0.3	0.4	0.6	0.4
14–1 d BD	–0.7	0.4	–0.3	0.4	–0.8	0.4	–0.3	0.4
0–14 d AD	–1.5***	0.4	–1.7***	0.4	–2.1***	0.5	–1.3***	0.4
15–28 d AD	–1.4**	0.5	–1.2**	0.4	–1.9***	0.5	–1.3**	0.4
29–42 d AD	–1.4**	0.5	–1.2**	0.4	–1.4**	0.5	–1.1**	0.4
> 42 d AD	–1.6**	0.4	–1.4***	0.4	–1.6***	0.5	–1.6***	0.4
Healthy cow	–0.7*	0.4	–1.3***	0.4	–1.5	0.4	–1.6***	0.4
Total loss[3]	–348.2	5.6%[4]	–299.6	4.3%[4]	–352.4	4.8%[4]	–328.6	4.4%[4]

[1]The comparison is to the cow's own milk yield more than 4 wk prior to the clinical onset of the disease. Season of calving and stage of lactation were included in each model as fixed effects.

[2]Period when the test day milk sample was collected with respect to the diagnosis of mastitis. BD = before diagnosis, and AD = after diagnosis.

[3]The total loss was calculated assuming a 305-d lactation and mastitis occurring on d 90 after calving.

[4]Percentage loss, calculated from the overall yield of 305-d lactation.

*$P \leq 0.05$.

**$P \leq 0.01$.

***$P \leq 0.001$.

TABLE 4. Effect of the occurrence of mastitis after d 120 on milk yield (kilograms) of 24,276 Finnish Ayrshire cows that calved in 1993 and were followed for one lactation.[1]

	Parity							
	1		2		3		4+	
Effect[2]	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
28–15 d BD	–0.4	0.2	–0.8***	0.3	–0.9***	0.3	–0.2	0.3
14–1 d BD	–0.5*	0.2	–1.1***	0.2	–1.3***	0.3	–0.7*	0.3
0–14 d AD	–1.0***	0.3	–1.8***	0.3	–2.4***	0.4	–1.8***	0.4
15–28 d AD	–0.5	0.3	–0.8**	0.3	–2.1***	0.4	–1.4***	0.4
29–42 d AD	–0.7*	0.3	–1.5***	0.4	–2.4***	0.5	–1.4***	0.5
> 42 d AD	–0.7*	0.3	–1.2***	0.3	–2.3***	0.4	–2.5***	0.4
Healthy cow	–0.9***	0.2	–1.4***	0.2	–1.9***	0.3	–1.6***	0.3
Total loss[3]	–109.9	1.8%[4]	–219.6	3.1%[4]	–387.3	5.2%[4]	–356.7	4.8%[4]

[1]The comparison is to the cow's own premastitis milk yield more than 4 wk before the clinical onset of the disease. Season of calving and stage of lactation were included in each model as fixed effects.

[2]Period when the test day milk sample was collected with respect to the diagnosis of clinical mastitis. BD = before diagnosis, and AD = after diagnosis.

[3]The total loss was calculated assuming a 305-d lactation and mastitis occurring on d 150 after calving.

[4]Percentage loss, calculated from the overall yield of 305-d lactation.

*$P \leq 0.05$.

**$P \leq 0.01$.

***$P \leq 0.001$.

in 305-d yield to be greatest when clinical mastitis occurred before the peak. Also, Lescourret and Coulon (13) reported that the impact of mastitis appeared to be more marked in early lactation than in late lactation. These results are in agreement with our results in general, which also suggest that the losses caused by mastitis were greatest when mastitis occurred in early lactation (before the peak). Yield of the oldest cows seemed to be most affected when mastitis occurred before the peak, whereas the youngest cows (parity 1) had the greatest losses of milk caused by mastitis between the peak and d 120.

Analysis with Herd as Random Effect

Limited checks on adequacy of grouping herd and cow (herd) effects showed no substantive differences; the estimates with herd as a random effect did not differ meaningfully from the results obtained without herd as a random effect (results not shown). Therefore, we can be confident that the results presented in the tables are valid.

General discussion. In general, we found that milk yield was significantly affected by mastitis; the reduction in 305-d yield was estimated to vary between 1.8 and 7.4 %. However, it is possible that we underestimated the true effect. If a cow had a severe case of mastitis on a test day, it is possible that no milk measures were taken from her on that day. Also, she might have been culled early in lactation due to mastitis before any milk measures were taken. Both of these scenarios would cause underestimation of the real loss.

Deluyker et al. (7) estimated that occurrence of clinical mastitis is associated with 5% milk yield loss, which is in agreement with our estimates. Several other studies have also reported that clinical mastitis has a detrimental effect on milk yield (1, 6, 12, 16). When mastitis occurred during late lactation, the yield had already started to decline 2 to 4 wk prior to the clinical onset of mastitis; however, the greatest reduction was right after diagnosis. After the cow had contracted mastitis, her milk yield did not return to the premastitis level but remained significantly lower throughout the rest of the lactation. Also, Lescourret and Coulon (13) reported that in more than one-third of the cases of mastitis, milk yield was affected for an extended period. Bunch et al. (4) even suggested that once a cow has contracted mastitis, it is unlikely to achieve its full potential for milk yield in the next lactation.

The results from all of these analyses clearly showed that cows with mastitis yielded more than did their healthy counterparts. The daily yield of the healthy cows was, on average, 0.7 to 1.9 kg less than the premastitis yield of the cows that contracted mastitis during the lactation (Tables 2 to 4). Therefore, it is of great importance to carefully consider the reference level used when interpreting results from an analysis estimating the effects of mastitis on milk yield. Direct comparison of the yield of cows with mastitis with that of healthy cows and interpretation of that as a loss caused by mastitis would most likely underestimate the effects of the disease.

One of the strengths of this study was the comprehensive data base with veterinary diagnosed diseases. Because of the large data set, we were able to include in the study cows with no diseases at all and cows with only mastitis but no other disease. The effects of mastitis on milk yield were thus not confounded by any other diseases. Also, a mixed model analysis with repeated measurements is the most sophisticated and accurate method currently available to measure milk loss caused by disease. It allows researchers to detect short-term effects and also to estimate milk losses both before and after clinical mastitis. A good choice for a reference group for estimation of milk loss, when mastitis occurs early in the lactation and cows do not have any unaffected milk measures taken before the disease, was to use the premastitis milk yield of cows contracting mastitis later during the lactation as the comparison.

CONCLUSIONS

The daily losses because of clinical mastitis varied between 1.0 and 2.5 kg during the first 2 wk after the diagnosis of the disease, and the overall loss because of mastitis over the lactation varied between 110 and 552 kg and depended on parity and the time of mastitis occurrence. When mastitis occurred during late lactation, the decline of milk yield started 2 to 4 wk prior to the onset of the clinical mastitis and suggested the presence of subclinical mastitis. Mastitis has a long lasting effect on milk yield; after contracting mastitis, a cow was not able to reach her premastitis milk yield during the rest of the lactation.

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