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# MASTITIS MANAGEMENT USING A MONITORING SYSTEM BASED ON SOMATIC CELL COUNT

H. Hogeveen, T. J. G. M. Lam, E. G. Grijsen, O. C. Sampimon

**Summary**

Participants from most Dutch organisations active on mastitis extension and research co-operated to create a structured approach for mastitis control. The concept is based upon a management circle, in which goals are set, a planning is made, and the mastitis parameters and preventive measure are monitored and evaluated. In this concept, collection of data for the monitoring process must be easy and as labour-efficient as possible.
Many farmers collect individual somatic cell counts (SCC) regularly. These data were used to add two new parameters to existing parameters: percentage of cows with an increased (> 250.000 cells/ml) SCC and percentage of cows with a new increased SCC (> 250,000 cells/ml in current test day milking and <= 250,000 cells/ml in the previous test day milking). SCC data over three years from 309 randomly selected dairy farms and 50 dairy farms with mastitis problems were used to gain more insight in the values of these new parameters. On the randomly selected dairy farms, on average, 21.3% (SD 16.2) of the sampled cows had an increased SCC. The percentage of new cows which had an increased SCC, was 8% (SD 10.5). The value of these parameters were slightly higher for the dairy farms with mastitis problems.

*Introduction*

Improvements in mastitis control should be directed towards a decreased duration of each mastitis case and a decreased infection rate (Natzke, 1981). A decreased duration can be reached by fast and effective detection of clinical and subclinical mastitis, followed by a proper therapy. A decreased infection

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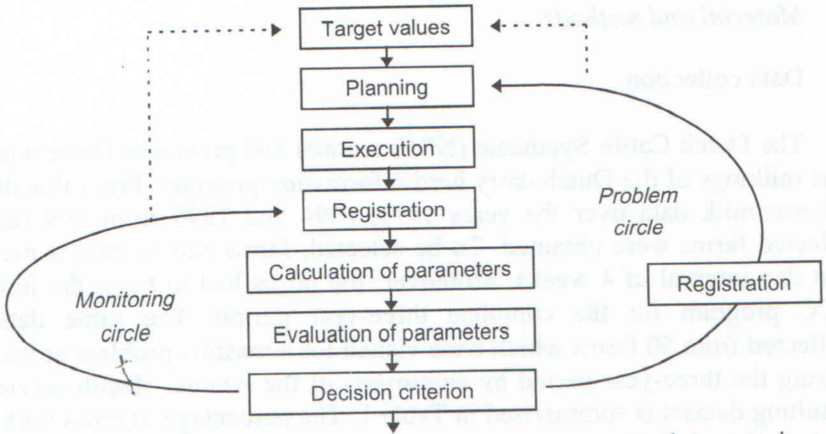
H. Hogeveen, Research station for cattle sheep and horse husbandry, Runderweg 6, 8219 PK Lelystad, The Netherlands; T. J. G. M. Lam, Department of herd health and reproduction, Faculty of Veterinary medicine, Utrecht University, PO box 80151, 3508 TD Utrecht, The Netherlands; E. G. Grijsen, Agricultural telematics centre, Agro business park 58, 6708 PW Wageningen, The Netherlands; O. C. Sampimon, Animal health service, PO box 9, 7400 AA Deventer, The Netherlands.

rate can be reached by preventive measures, e.g., a good milking method, hygiene on the farm and a properly functioning milking machine. On both areas much knowledge is available and can be applied in mastitis management. Part of good mastitis management is the monitoring of the mastitis status so that effective measures may be taken as fast and effective as possible. Monitoring mastitis on an individual cow basis is becoming fairly common on dairy farms. To monitor subclinical mastitis measurements of individual somatic cell counts (SCC) as part of a dairy herd information program can be used. This provides the dairy farmer with useful data on the infection status of individual cows (Reneau, 1986). Mastitis can not only be a cow problem, when a farm has too much cows with mastitis, there is a herd mastitis problem. This type of problem is often not recognised soon enough. Monitoring mastitis on a farm level is therefore also important and may help the dairy farmer to take preventive measures before the problem grows out of hand.

In the Netherlands a project has been initiated to develop a health planner, which can support the dairy farmer in mastitis management (Lam and Grijsen, 1997). This mastitis planner is based upon a common management planning circle. It consists of tools to obtain the current mastitis prevention status of a farm, tools to register preventive measure that were planned, a tool to monitor the mastitis status of a farm and an scheme to analyse occurring herd mastitis problems. All tools are extensively described and much background knowledge on mastitis is given. An important part of the planner was the development of parameters for monitoring the herd mastitis status. Some of these parameters are based upon individual SCC measurements. The aim of this paper is to describe and discuss these parameters based upon individual SCC in the context of the management planning circle.

## The management planning circle

The health planner is based upon a management planning circle (Fig. 1). The management planning circle starts with the definition of goals, represented by target values. Given the goals, management strategy is planned and executed. From that point on, the monitoring circle starts, consisting of the recording, calculation and evaluation of monitoring parameters. Based upon a pre-set decision criterion, the monitoring circle will be continued or the problem circle will be entered. In the problem circle, an analysis protocol has to be carried out in order to find possible causes for the inability to meet the pre-set targets and, if necessary, adjust the planning. Target values are by the farmer and his consultants based on the specific situation on the farm and the personal goals of the farmer. If necessary these can be adapted in time.




Standard values, representing the average value of a parameter in a certain area or certain type of farm, can be helpful while determining a target value. The decision criterion is set in such a way that the probability to enter the problem circle unnecessary is small. Standard, a 95% confidence interval is used. To calculate this interval and thus a proper decision criterion, information on variation and distribution of the parameters is therefore necessary to define proper decision criteria.

Primary mastitis parameters

In order to be successful, the parameters used for monitoring the mastitis status of a farm must be easy to measure, objective, time effective and should cover every all mastitis problems. Five parameters have been defined and these are referred to as primary mastitis parameters:

- incidence of clinical mastitis
- percentage of cows culled because of udder problems
- bulk milk SCC
- percentage of cows with an individual SCC higher than 250,000 cells/ml
- percentage of cows with an individual SCC higher than 250,000 cells/ml and a SCC smaller than or equal to 250,000 cells/ml during the previous test milking.

For the primary mastitis parameters on clinical mastitis, culling and bulk milk SCC, enough information is to available to set standard values. However, on the parameters referring to individual SCC, at the herd level no standard values, is known.

## *Material and methods*

### Data collection

The Dutch Cattle Syndicate (NRS) records and processes the results of all test milkings of the Dutch dairy herd information program. From this database all test milk data over the years 1993, 1994 and 1995 from 309 randomly selected farms were obtained. To be selected, farms had to have a maximum test day interval of 4 weeks. Moreover, the farms had to be in the individual SCC program for the complete three-year period. The same data were collected from 50 farms which were visited for a mastitis problem at least once during the three-year period by employees of the Animal Health service. The resulting dataset is summarised in Table 1. The percentage of cows with a high and new high SCC were calculated per farm per test day. High SCC was defined as a SCC above 250.000 cells/ml. A cow was defined to have a new high SCC when she had a SCC of more than 250.000 cells/ml in the current test day milking and a SCC smaller than or equal to 250.000 cells/ml in the previous test day milking.

Four seasons were defined: spring (March-May), summer (June-August), fall (September-November) and winter (December-February). Per test-day milking, the bulk milk SCC was estimated by calculating the average individual SCC, weighed by milk yield.

### Analyses

For the analyses only test days with more than 10 milkings were used. Minimum, maximum, mean and standard deviation of the percentage of cows with high new high SCC were calculated as well for the randomly selected as the problem farms. Differences between the problem and the random farm were analysed using the two-sample t-test. To estimate the effect of year, season, mastitis problem farm and farm size on the probability of a cow to have a high or new high SCC, the following generalised linear mixed models were built using a binomial distribution and a logit link:

$$Y_{ijklm} = u + F_i + SS + Year_j + S_k + P_l + S_k{*}Y_j + S_k{*}SS + S_k{*}P_l + Y_j{*}P_l + e_{ijkl}$$

where:

$Y_{ijklm}$ probability that cows had a high or a new high SCC during a test day milking

u overall mean

$F_j$ random effect of farm i (n = 352)

SS fixed effect for sample size
$Year_j$ fixed effect for year j (1993,1994,1995)
$S_k$ fixed effect for season k (spring, summer, fall, winter)
$P_l$ fixed effect for mastitis problem I (no, yes)
$S_k*Y_j$ fixed effect for the interaction between season k and year j
$S_k*SS$ fiksed effect for the interaction between season k and sample size
$S_k*P_l$ fixed effect for the interaction between season k and mastitis problem I
$Y_j*P_l$ fixed effect for the interaction between year j and mastitis problem I
$e_{ijkl}$ random error term

The same model, using a log normal distribution and a logarithm link was built for the estimated bulk milk SCC. This type of generalised linear mixed model was also used to test the possibility to predict the bulk milk SCC of the next test-day by the current values of percentage of cows with a high and a new high SCC:

$$Y_{ijklm} = u + F_i + S_j + Hi + NwHi + Hi*NwHi + e_{ij}$$

where:

$Y_{ijklm}$ bulk milk SCC during the next test day milking
u overall mean
$F_j$ random effect of farm i (n = 352)
$S_j$ random effect of season j (spring, summer, fall, winter)
Hi fixed effect for percentage of cows with a high SCC
NwHi fixed effect for percentage of cows with a new high SCC
Hi*NwHi fixed effect for interaction between Hi and NwHi
$e_{ij}$ random error term

The models were checked for validity by plotting the residuals against the fitted values. All analyses were carried out using the Genstat statistical software (Genstat Committee,1993)

### *Results*

Minimum, maximum, mean and standard deviations of the primary mastitis parameters cows with high SCC and cows with new high SCC are given in Table 1. The prevalence of high SCC was 20.7% for the random farms and 24% for the problem farms. Corresponding parameters were respectively 9.6 and 10.7% for the new high SCC. These differences between random and problem farms were small but significant ($P < 0.05$).

Table 1. - DESCRIPTIVE STATISTICS FOR THE PRIMARY MASTITIS PARAMETERS PERCENTAGE OF COWS WITH A HIGH SCC AND PERCENTAGE OF COWS WITH A NEW HIGH SCC

| | High SCC (%) | | New high SCC (%) | |
|---|---|---|---|---|
| Mean | 20.7 | 24 | 9.6 | 10.7 |
| Standard deviation | 11.8 | 12.1 | 8.2 | 8.4 |
| Minimum | 0 | 0 | 0 | 0 |
| Maximum | 100 | 73.3 | 100 | 57.1 |
| 25th percentile | 12.2 | 14.9 | 4.1 | 5 |
| 50th percentile (median) | 19 | 22 | 7.8 | 9 |
| 75th percentile | 27.5 | 31.6 | 13 | 14.3 |
| No. of milkings | 10701 | 1391 | 10700 | 1391 |

Also the distribution of the prevalence of high and new high SCC did not differ very much between randomly selected and mastitis problem farms (Fig.1 and Fig. 2).

All single terms were significant in the generalised linear mixed models for high SCC, new high SCC and estimated bulk milk SCC (Table 2). For all three response variables (high SCC, new high SCC and bulk milk SCC), the interaction term season*year was significant. The other two interaction terms for season, season*sample size and season*problem were only significant for new high SCC. The interaction term year*problem was not related to any of the response variables.

An increasing year number, gave a lower probability of high SCC and new high SCC and a lower estimated bulk milk SCC, indicating an improving udder health, in terms of SCC, over the years.

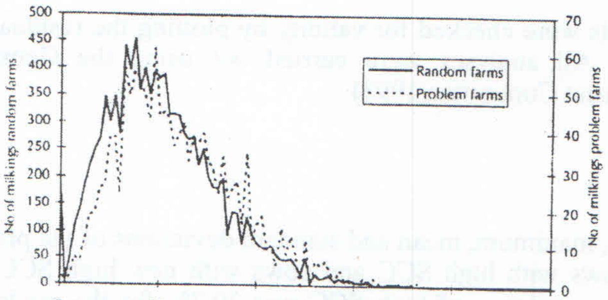



Figure 1. - DISTRIBUTION OF THE PREVALENCE OF HIGH SCC FOR RANDOMLY SELECTED FARMS (LEFT Y-AXIS) AND FARMS WITH A MASTITIS PROBLEM HISTORY (RIGHT Y-AXIS)

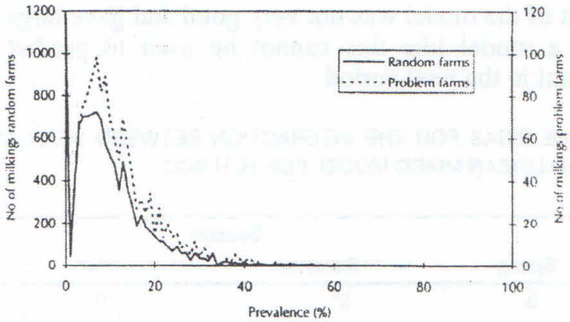



Figure 2. - DISTRIBUTION OF THE PREVALENCE OF NEW HIGH SCC FOR RANDOMLY SELECTED FARMS (LEFT Y-AXIS) AND FARMS WITH A MASTITIS PROBLEM HISTORY (RIGHT Y-AXIS)

Table 2. - RESULTS OF THE GENERALIZED LINEAR MIXED MODELS FOR HIGH SCC, NEW HIGH SCC AND ESTIMATED BULK MILK SCC. PER FIXED EFFECT THE DEGREES OF FREEDOM (DF) AND WALD STATISTIC ARE GIVEN

| | High SCC | | New high SCC | | Estimated bulk milk SCC | |
|---|---|---|---|---|---|---|
| | DF | Wald | DF | Wald | DF | Wald |
| Season | 3 | 186.7** | 3 | 238.2** | 3 | 85.1** |
| Sample size | 1 | 71.5** | 1 | 671.8** | 1 | 12.6** |
| Problem | 1 | 4.8* | 1 | 6.6** | 1 | 6.1* |
| Year | 2 | 64.4** | 2 | 805.8** | 2 | 67.3** |
| Season*sample size | 3 | 7.7 | 3 | 31.7** | 3 | 5 |
| Season*problem | 3 | 4.6 | 3 | 10.2** | 3 | 10.1** |
| Season*year | 6 | 179.2** | 6 | 475** | 6 | 79.1** |
| Year*problem | 2 | 3.7 | 2 | 2.4 | 2 | 2.9 ' |

* Significant with P < 0.05

** Significant with P < 0.01

There was no significant difference between individual seasons. However, when compared within year, there was a significant difference between the effect of summer on the probability of a high SCC between 1993, 1994 and 1995 (Table 3). The prevalence of cows with a high SCC was higher in the summer of 1995 compared to the summers of 1993 and 1994. The same effect was visible for the fall.

The three fixed effects (percentage of cows with a high and a new high SCC and their interaction) in the generalised linear mixed model for the estimated bulk milk SCC in the next test day, were all statistically significant.

However, the fit of the model was not very good and gave large residual errors, indicating that a model like this cannot be used to predict the bulk milk somatic cell count in the next period.

Table 3. - RELATIVE RISKS FOR THE INTERACTION BETWEEN YEAR AND SEASON FOR THE GENERALISED LINEAR MIXED MODEL FOR HI H SCC

| | Season | | | |
|---|---|---|---|---|
| Year | Spring | Summer | Fall | Winter |
| 1993 | 0 | $0^{x}$ | $0^{x}$ | $0^{x}$ |
| 1994 | $0^{a}$ | $0.075^{b,y}$ | $-0.002^{x}$ | $-0.076^{c,y}$ |
| 1995 | $0^{a}$ | $0.192^{b,z}$ | $0.199^{b,y}$ | $-0.016^{a,x}$ |

$^{a,\,b,\,c}$ Different letters in the same row indicate a significant difference with P < 0.05

$^{x,\,y,\,z}$ Different letters in the same column indicate a significant difference with P < 0.05

### *Discussion*

The primary mastitis parameters defined in the mastitis planner, cover all types of herd mastitis problem. For obvious reasons, clinical mastitis is an important parameter. Bulk milk SCC is important because it gives a summary of SCC situation of a herd. For individual cows, a SCC of 250.000 cells/ml can be regarded as abnormal (Schepers et al., 1997). Therefore, it is possible that a herd has many cows with high (> 250.000 cells/ml) SCC, while the bulk milk SCC still is at an acceptable level. Therefore, the percentage of cows with a high SCC may be of value to detect possible herd mastitis problems. Moreover, in case of a problem with SCC, it is important to know whether the same cows are causing the problems or whether the cows with an elevated SCC differ. This is represented by the parameter percentage of cows with a new high SCC. In the first case the treatment of animals with problems or the culling strategy may not be optimal, leading to a long duration of a mastitis case. In the second case, the infection risk is high and the problems may be caused by, for instance, malfunctioning milking machine or an insufficient defence mechanisms.

One of the parameters, bulk milk SCC, is already available on all Dutch dairy farms. The parameters presented in this paper, high and new high SCC, can easily be calculated from results of the dairy herd information program and will cost the farmer not much time to collect. The parameters clinical mastitis and culling because of mastitis problem request more discipline from the farmer. Moreover it is to be expected that not all farmers will use the same definition for clinical mastitis and that incidences between farms will occur.

However, because the parameters are only used to compare within farms this will not be a problem, as long as the farmer uses his own definition consequently. Moreover, research showed that, when instructed properly, farmers are well capable of diagnosing clinical mastitis correctly (Lam et al., 1993).

The average prevalence of high and new high SCC found in this study are somewhat lower than the 29 and 15% found in Canada (Dohoo and Morris, 1993). However, the Canadian study used a threshold of 200,000 cells/ml while the threshold in our study was 250,000 cells/ml. The difference, in terms of prevalence of high SCC and new high SCC between random and problem farms was not very large. This is possibly caused by the fact that the study is carried out over three years, while the problem farms only had a mastitis problem during a relatively small period of the three years. Therefore the effect of the problem was not large in the three-year average of the farms.

The standard deviation found for high SCC and new high SCC was rather large. This means that when the decision criteria for the parameters high SCC and new high SCC are decision criterion have a wide 95% confidence interval. With an increasing farm size the confidence interval will become slower. This same principle occurs when data from more than one teat day are used to take a decision. This problem occurs not only for the parameters based on SCC. Because of the lower prevalence, the confidence intervals are even wider for a parameter like clinical mastitis. Therefore, in the mastitis planner, 95% confidence intervals for the primary mastitis parameters are given for various farm sizes and for parameters calculated over one test day milking, the test-day milkings in the last three months, in the last 6 months and in the last 12 months.

The sample size in the generalised linear mixed models resembled the farm size. Large farms have more cows measured during a test day. The negative effect of sample size indicates that larger farms have less problems with SCC. The negative effect of year on SCC problems is coherent with research of Schukken et al. (1990, 1992) who described a decreasing bulk milk SCC over the years. The interaction between season and year may be due to the high temperatures in the summers of 1994 and 1995. These high temperatures gave an overall higher bulk milk SCC in the Netherlands (unpublished data).

In an initial test phase, the mastitis planner has been tested on 25 dairy farms for 4 months. The dairy farmers were all satisfied with the method of disease management propagated by the mastitis planner. Currently, the mastitis planner is being tested on approximately 250 dairy farms for a complete year, in order to be able to measure effects of the usage of the health planner on the udder health situation.

*Conclusions*

A mastitis planner has been developed, based upon the management planning circle. To monitor mastitis in this planner, five parameters have to be registered: clinica mastitis, culling because of udder problems, bulk milk SCC, cows with a high SCC and cows with a new high SCC. For the latter two parameters not much information was available and research has been carried out into them. The prevalence was respectively 20.7 (SD 11.8) and 9.6% (SD 8.2) for high SCC (> 250,000 cells/ml) and new high SCC. SCC were influenced by the herd size, season, year and history of a mastitis problem.

*Acknowledgements*

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## UPRAVLJANJE MASTITISOM PRIMJENOM SISTEMA PRAĆENJA NA OSNOVI BROJA SOMATSKIH STANICA

**Sažetak**

Sudionici iz većine holandskih organizacija koji rade na opsegu i istraživanju mastitisa zajedno su radili na stvaranju strukturiranog pristupa suzbijanju mastitisa. Zamisao se temelji na krugu upravljanja u kojem su postavljeni ciljevi, obavljeno planiranje te praćeni i ocijenjeni parametri mastitisa kao i preventivne mjere. Prema toj zamisli zbirka podataka za proces praćenja mora biti laka i što je moguće radno djelotvornija.

Mnogi farmeri redovito prikupljaju pojedine brojeve somatskih stanica (SCC). Ti su podaci upotrijebljeni za dodavanje dvaju novih parametara postojećim parametrima: postotak krava s povećanim SCC-om (> 2500,000 stanica/ml) i postotak krava s novim povećanjem SCC-a (> 250,000 stanica/ml u aktualnom testu dnevne mužnje i < = 250,000 stanica/ml u prijašnjem testu dnevne mužnje).

Upotrijebljeni su trogodišnji SCC podaci sa 309 nasumce izabranih mljekarskih farmi i 50 mljekarskih farmi s problemima mastitisa da bi se dobio bolji uvid u vrijednosti tih novih parametara. Na nasumce izabranim mljekarskim farmama u prosjeku 21.3% (SD 16.2) uzoraka krava imao je povećani SCC. Postotak novih krava koje su imale povišeni SCC bio je 8% (SD 10.5). Vrijednosti tih parametara bile su nešto više na mljekarskim farmama s problemima mastitisa.

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