Use of Individual Cow Somatic Cell Counts and Bulk Tank Samples to Monitor Herd Mastitis Status

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With the advent of automated cell counting, there has been a proliferation of milk somatic cell count (SCC) data for both bulk tank samples and individual cows. The optimal use of this data in monitoring mastitis is still being debated. The purpose of this paper is to discuss the use of SCC data from both individual cow and bulk tank samples for monitoring mastitis on a herd basis.

The influx of somatic cells into the mammary gland is a sign of inflammation, however the determinants of milk SCC are still not completely understood. Current knowledge of SCC has been reviewed in several recent papers[1,2,3]. Briefly, the major determinants are:

INFECTION—SCC increases in the presence of infection. The degree of increase varies with the pathogens involved, the cow and the number of quarters affected. Once elevated, the SCC may remain elevated long after the infection is cleared.

AGE—The intensity of the SCC response to infection increases with exposure to pathogens. The average SCC of heifers will be lower than that of older cows since heifers have had less exposure to pathogens and have a lower infection prevalence.

STAGE OF LACTATION—SCC is elevated at parturition. In the absence of infection, SCC will return to low levels by 2-3 weeks into lactation. As lactation progresses, SCC will slowly increase, but this is most likely the result of increased exposure to pathogens and infection prevalence.

PRODUCTION—Milk volume has an effect on SCC concentration (SCC/ml). Total SCC (concentration x milk yield) varies less than concentration alone. At high production levels, SCC concentration may be lowered by dilution. Similarly, water deprivation will decrease milk yield which increases SCC in the absence of infection[4].

DIURNAL VARIATION—There is a daily cycle, with the lowest SCC observed just before milking and the highest observed just after milking. This cycle reflects the effect of milk production on SCC. SCC is usually lower just before the morning milking, corresponding to the longer inter-milking period.

MANAGEMENT—Several studies have examined herd effects on individual cow SCC. Some of the variation in herd SCC reflects differences in management practices, such as post-milking teat dipping and dry cow therapy. Management plays an indirect role in determining SCC because of its effect on exposure and new intramammary infection rates. It is not known whether particular management techniques may also have a direct effect on SCC.

SEASON—SCC tends to be highest in summer and lowest in winter, for reasons not yet completely known.

DAY-TO-DAY VARIATION—Some of the day to day variation in SCC has not been explained.

In summary, the single most important determinant of SCC is infection. However, SCC alone is a relatively poor predictor of infection on the individual cow level[5]. This predictive value of SCC is hindered by the difficulty of defining the limits of "normal", and wide variations in the SCC response to specific mastitis pathogens. However, on a group or herd level, SCC may be a more useful tool for monitoring mastitis status. There are two approaches to a herd SCC. One is to sample the bulk tank. The other way is to measure the SCC of all herd members and calculate some type of summary statistic for the herd.

Direct or indirect measurement of the bulk tank somatic cell count (BTSCC) is relatively easy, and may be provided by the milk plant at no charge to the dairyman. The BTSCC provides a quick estimate of the herd infection status, since infection is the primary determinant of SCC. However, the BTSCC is a biased measurement. Ideally it represents an average of the SCC of all of the milking cows in the herd. However, the contribution of each individual cow is weighted by her milk production. Therefore, a high producing cow will have a greater effect on the BTSCC than a low producing one. Secondly, the BTSCC ignores fresh cows, clinical cows, treated cows, and any cows whose milk is not being added to the bulk tank. Thirdly, the BTSCC shows considerable daily variation, and is affected by sampling technique and storage.

Despite these limitations, the BTSCC or an indirect measure of the BTSCC, like the Wisconsin Mastitis Test (WMT), offers a relative index of herd mastitis status. It is best used by observing the trends over time as a monitor of the overall mastitis control program. The BTSCC should be below 300,000 (a WMT of 8-10). In a study involving 85 herd visits, Eberhart calculated a highly significant regression between quarter infection prevalence (% quarters infected) and BTSCC[6]:

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Quarter infection prevalence = 3.3 x - 0.42
(x = BTSCC expressed in 100,000/ml)

By this formula, a BTSCC of 300,000 represents a herd quarter infection prevalence of about 10%.

In comparison, individual cow SCC is expensive, costing $.12 to .15 per cow per month, but it provides individual as well as group level data. Individual cow SCC is now widely available through Dairy Herd Improvement Associations (DHI). The individual cow SCC is usually reported as either an absolute number or a relative score. The National Cooperative Dairy Herd Improvement Program has adopted a 0-9 scale based on a $\log_2$ transformation of the absolute SCC number (Figure 1). This score will now be used by all DHI processing centers in reporting SCC's in order to aid in the interpretation of SCC data.

FIGURE 1: Somatic Cell Count Log Scores.

Somatic Cell Count (X 1,000)	$\log_2$ Score
0 — 18	0
19 — 35	1
36 — 71	2
72 — 141	3
142 — 283	4
283 — 565	5
566 — 1,130	6
1,131 — 2,262	7
2,263 — 4,523	8
4,524 — 9,999	9

The individual cow SCC also has some biases, because it measures composite milk SCC. Composite SCC is not a strict average of the SCC of each quarter, but rather a weighted average of the individual quarter SCC concentration and quarter milk yield. Therefore, quarters with higher production will have a greater contribution to the composite SCC than quarters with lower production. For the same reason, infection in multiple quarters will have a greater impact on composite SCC than infection in a single quarter. The composite nature of the individual cow SCC is one of the main problems in the use of the SCC as an individual cow diagnostic tool.

On a herd basis, individual cow SCC's can be examined in terms of an average or in terms of a distribution of counts. For example, the five cows in figure 2 can be described in terms of an arithmetic mean, a geometric mean, or on the basis of a categorical description. The arithmetic average (or mean) SCC is calculated by adding together all of the individual absolute SCC's and dividing by the number of cows. The major drawback of this method is that a single high SCC cow can have a tremendous effect on the average. This bias can be lessened by transforming the SCC's as with the DHI 0-9 scale, and averaging the scores of the individual cows. This is an average of the log SCC's and is called the geometric mean. Some DHI processing centers report a weighted herd average SCC which also weights the individual cow SCC's or score by their milk production. Use of these types of herd average SCC's provide an estimate similar to the BTSCC. However, the weighted herd SCC has the advantage of taking into account all milking cows. Averages have one major drawback. They estimate the mean score but give no indication of the actual distribution of the cows. The mean of 1 high cow and 4 low cows could be the same as the mean of 2 medium high cows and 3 low cows. In other words, the mean alone does not allow identification of the degree of the problem.

FIGURE 2: Alternatives for Expressing Herd Somatic Cell Count (SCC)

Cow #	SCC*10^3	SCC Score	Category
1	80	3	low
2	23	1	low
3	129	3	low
4	220	4	low
5	2,531	8	high

Arithmetic Mean SCC = 597,000
Geometric Mean SCC = 3.8 = 174,000
Category = 80% Low

A third alternative for describing herd SCC is to calculate the percent of cows in specific SCC categories, such as normal and abnormal. Unfortunately the exact dividing point between normal and abnormal is still debated, and depends on other determinants such as age and stage of lactation as well as infection. Therefore, the use of categories such as low/med/high provide a description of the overall distribution of SCC's. The different processing centers have developed their own categories. DHI Provo uses a low/medium/high score. Low includes scores 0-4, medium 5-6, and high 7-9. DHI Raleigh uses 4 categories: 0-3, 4-5, 6, 7-9. Mid-States uses three categories: <300,000, 300,000-600,000, and >600,000. Use of categories provides the most unbiased herd SCC estimate, because they address the actual distribution of SCC's.

On a herd basis, individual cow SCC's can be reported in a number of ways. This paper will concentrate on the summary information which is reported on the herd summary sheet for many processing centers: the monthly distribution of SCC's, the herd average SCC's and the stage of lactation profile. For other areas, such as the Mid-States, this information is reported on a separate somatic cell report.

Each montly report provides a glimpse of the mastitis status of the herd at that single point in time. Figure 3 provides examples of the monthly report from three different processing centers. In general, over 90% of the heifers, 85% of the 2nd lactation cows and 80% of the older cows should score between 0-4 (SCC less than 283,00).

As with the single BTSCC, there is a considerable variability in the distribution of individual cow scores. Therefore, examination of the trends in the herd is necessary as well as the individual month (figure 4). Optimally, there should be little variation in the percent of the cows in the low categories. The rolling herd average SCC distribution will be a more

FIGURE 3: Herd Somatic Cell Count Distribution for the Current Month.

DHI Provo:

	Percent SCC		
LACT #	Low (0-4)	Med (5,6)	High (7-9)
1	93	6	1
2	89	10	2
3+	71	21	8
T	82	14	4

DHI Raleigh:

	Percent Cows SCC Score			
LACT #	0-3	4,5	6	7-9
	<141,000	141,000 — 565,000	566,000 — 1,130,000	>1.130,000
1	67	24	4	5
2+	32	33	15	20
T	44	30	11	15

DHI Mid-States:

	Percent Cows
Below 300,000	44
300,000 — 600,000	25
Over 600,000	31

FIGURE 4: Herd Somatic Cell Count Summary.

Date	Percent SCC		
	Low	Med	High
10-25	85	12	3
11-20	88	10	2
12-27	81	14	5
1-28	82	13	5
2-25	83	13	4
3-24	76	19	5
4-18	85	11	4
5-26	88	10	1
6-26	91	7	2
7-24	91	8	1
8-28	80	16	4
9-25	82	14	4
Rolling Herd Average	84	12	3

stable reflection of the SCC status, as it averages the present month's score with the previous 11 month's scores. Graphing of the rolling herd average SCC may facilitate the identification of herd trends.

Although infection is the single most important determinant of SCC, the monthly report should also be evaluated in terms of the other known determinants of SCC. The freshening of a large number of cows in a single month can cause a large decrease in the percent cows in the low category, but may be unrelated to infection. A herd with a high infection prevalence can improve their SCC distribution by increasing the proportion of heifers in the herd, because heifers tend to have lower SCC's than cows. Similarly, a herd which emphasizes 365 day lactation records, or maintains a number ET donors with long lactations will tend to have higher percentages of cows in the upper SCC category. These problems have led to the development of the stage of lactation profile.

The stage of lactation profile divides the herd by days in milk, and sometimes also by lactation number (Figure 5). SCC's should be highest in the first 2 weeks of lactation, decrease to the lowest level during the peak of lactation (6-8 weeks), and will rise slowly toward the end of lactation due to new infections. A herd profile which shows persistently high SCC after early lactation suggests persistent infections that are not being appropriately treated by dry cow therapy. A herd profile which shows SCC's increasing rapidly through lactation suggests a breakdown in the milking technique and control programs leading to an increased spread in the contagious mastitis pathogens. There is a distinct advantage to including a parity in the stage of lactation profile. Heifers should freshen with the lowest mastitis prevalence. Therefore, they should be the most sensitive indicators of contagious mastitis pathogen problems. Similarly, they should respond the most quickly to improvements in mastitis control.

FIGURE 5: Stage of Lactation Profile.

DHI Raleigh Example:

	Stage of Lactation Profile (Milking Cows)				
	Stage of Lactation (Days)	**Number of Cows**	**% of Milking Herd**	**Daily Average Prod. (lbs.)**	**Average SCC Score**
Cows	306 and Greater				
Heifers					
Cows	200-305				
Heifers					
Cows	100-199				
Heifers					
Cows	Fewer than 100				
Heifers					

In summary, individual cow SCC's offer a dynamic tool for the veterinarian. By using the monthly test results, following the change in herd SCC's over time, and analyzing stage of lactation profiles, the effectiveness of the mastitis control program within a herd can be monitored. The SCC

information may also be valuable in the subsequent identification of weaknesses in the control program.

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