Influence of Stages of Lactation, Parity and Season on Somatic Cell Counts in Cows

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ABSTRACT : The study was undertaken to find out the normal mean and variations in somatic cell count (SCC) of milk in crossbred and indigenous cows as influenced by stage of lactation, parity and season. On day of milk sampling the udders were tested for mastitis by California Mastitis Test (CMT). Only those cows, which were found negative in the CMT, were taken in the study. Paritywise differences in SCC were not significant between the 1st to 6th lactation and above. Similarly, stage of lactation effect, when tested at 30 day intervals, did not differ significantly. However, the seasons significantly ($p<0.05$) affected SCC count of milk. The SCC was lower during cold (1.10×10^5 cells/ml) and hot-dry (1.11×10^5 cells/ml) season then during hot-humid season (2.14×10^5 cells/ml). On an average SCC recorded were 1.26, 1.31, 1.54 and 1.61×10^5 cells per ml respectively in Tharparkar, Sahiwal, Karan Swiss and Karan Fries cows irrespective of stage of lactation, parity and season. Further, crossbred Karan Swiss and Karan Fries cows behave similar to the indigenous Tharparkar and Sahiwal cows but are more vulnerable to hot-humid climate then indigenous ones. Significant correlation between the SCC and milk yield during different stages of lactation (1.38 to 1.74×10^5 cells/ ml) and parity (1.47 to 1.63×10^5 cells/ ml) suggested that the SCC/ml of milk was higher during the later stages of lactation. ***(Asian-Aust. J. Anim. Sci. 2001. Vol 14, No. 12 : 1775-1780)***

Key Words : Somatic Cell Count, Lactation, Parity, Season, Cows

INTRODUCTION

Somatic cell counts (SCC) are being used as an index of the inflammatory condition of the udder. These are secreted during normal course of lactation in milk (Silva and Silva, 1994) and therefore are a valid indication of abnormal milk secretion, milk composition and mammary disease in dairy animals (Haenlein and Hinckley, 1995). Somatic cells in milk are of two types; sloughed epithelial cells from the udder and leucocyte from the blood. A number of factors like management, stage of lactation, parity and season influences secretion of SCC in milk of cattle, buffaloes and goats (Dulin et al., 1983; Randy et al., 1991; Muggli, 1995; Wilson et al., 1993; Wilson, 1994; Wilson et al., 1985; Lin and Chang, 1994). Mastitis results in decreased milk production and increased cost of treatment in dairy cows (Singh et al., 2001). A decrease in bulk milk somatic cell count can be used as an indicator in mastitis control programme (Suriyansathaporn et al., 2000). Considerable literature on SCC levels in milk of exotic cattle is available (Sheldrake et al., 1983; Marecus and Dale, 1994; Harmon, 1994). But information on mean and variations of SCC during different stages of lactation, parity and season in cows under tropical condition is not available. Moreover, official average SCC in milk of Zebu cows viz., Tharparkar (TP) and Sahiwal (SW) and of newly developed crossbred viz. Karan Swiss (KS) and Karan Fries (KF) cows being developed at NDRI (National Dairy Research Institute), is not available. The present study was therefore, undertaken to find out normal values of SCC and its variations, if any, during different stages of lactation, parity and season in indigenous and crossbred cows.

MATERIALS AND METHODS

The study was conducted on Indigenous (Tharparkar and Sahiwal) and crossbred (Karan Swiss and Karan Fries) cows maintained at the NDRI herd. These were offered ad lib green fodder (berseem and maize) and fresh water. The udders were tested for mastitis using modified California Mastitis Test (CMT, Teepol 0.5 ml, sodium hydroxide 1.5 g, bromothymol blue 0.01 g, distilled water 100 ml). The milk samples found negative for mastitis were used for the study. Milk samples were collected during morning (6:00 AM), noon (12:00) and evening (6:00 PM) from the crossbred KS and KF cows and during morning and evening from Tharparkar and Sahiwal cows. A total of 763 milks samples were collected from the lactating cows during hot-dry (May-June), hot-humid (August-September) and winter (December-January) season to determine the effect of stage of lactation, parity and season on SCC. The milk samples were grouped at 30 days interval based on the stages of lactation as 0-30 (1), 31-60 (2), 61-90 (3), 91-120 (4), 121-150 (5), 151-180 (6), 181-210 (7), 211-240 (8), 241-270 (9), 271-300 (10) and 301 & above (11). The parity of the cows were I, II, III, IV, V and VI & above. Somatic cell counts in milk was determined by the method of Das and Singh (2000). In brief 10 ul fresh milk sample was spread on a

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Received February 12, 2001; Accepted July 25, 2001

glass slide and was stained using methylene blue dye solution (0.6 g methylene blue, 40 ml tetrachloroethane, 95% ethyl alcohol and 6 ml glacial acetic acid) and the SCC were measured microscopically. The data were analysed using least square analysis of variance. Mean and standard errors and the correlations between the parameters, milk yield, stages of lactation, seasons and parity were also calculated (Snedecor and Cochran, 1980).

RESULTS

The milk yield and somatic cell counts in different breed during seasons, stages of lactation and parity have been presented in table 1, 2, 3 and 4, respectively. Overall mean values of SCC was higher ($p<0.05$) during first 30 days of lactation ($1.54\pm0.07\times10^5$ cells/ml), decrease during day 31-60 ($1.41\pm0.08\times10^5$ cells/ml) and therafter fluctuate upto day 300 of lactation (figure 1). However, overall changes in SCC during different stages of lactation were not statistically significant. Milk yield varied significantly ($p<0.01$) during different stages of lactation and was also negatively correlated ($p<0.05$) with somatic cell counts. The number of SCC was normally in the range of 1.0 to 1.5×10^5 cells/ml in all the stages of lactation except at 0-30th day of early lactation. During lactation the overall Mean±SE values of SCC were 1.26±0.06 and $1.31\pm0.04\times10^5$ and 1.54±0.07 and $1.61\pm0.03\times10^5$ cells/ml respectively, in Sahiwal, Tharparkar, KS and KF cows (table 1). The increasing number of lactation did not influence somatic cell counts but milk yield changes during parity were significant ($p<0.01$, figure 2). The number of cells was in the range of 1.47 to 1.63×10^5 cells/ml during all the parity. The SCC was negatively correlated with milk yield ($p<0.01$) during different parities. Somatic cell counts were

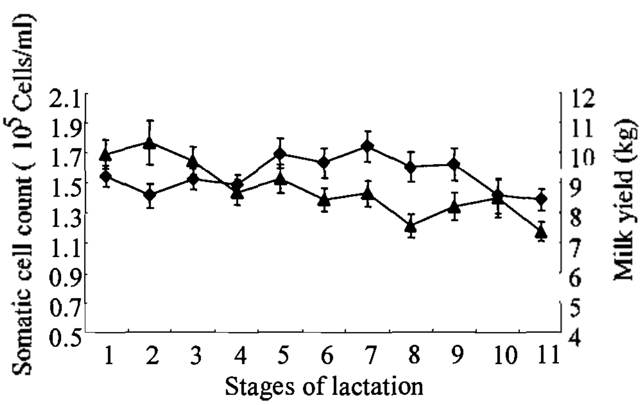

Figure 1. Effect of stage of lactation on somatic cell count (●) and milk yield (■)

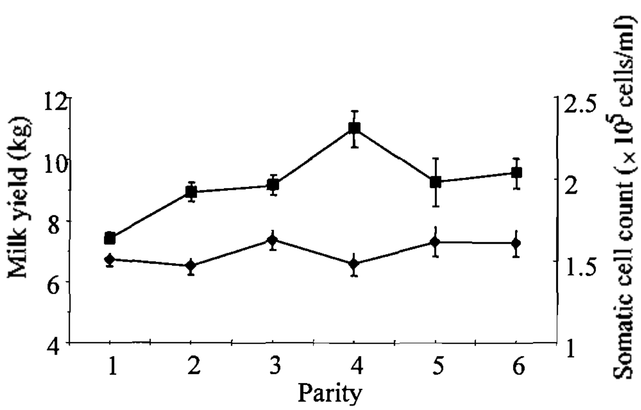

Figure 2. Effect of parity on somatic cell count (●) and milk yield (■)

Table 1. Breedwise somatic cell counts ($\times10^5$ cells/ml) and milk yield (kg) during different stages of lactation

Days of Lactation	Tharparkar		Sahiwal		Karan Swiss		Karan Fries	
	SCC	MY	SCC	MY	SCC	MY	SCC	MY
01-30	1.26±0.18	6.12±0.28	1.20±0.08	8.50±0.76	1.71±0.32	6.12±0.18	1.63±0.08	11.12±0.62
31-60	1.47±0.37	8.25±0.65	1.33±0.14	9.37±1.19	1.67±0.24	7.96±0.99	1.40±0.10	15.46±4.20
61-90	1.05±0.05	7.70±0.56	1.12±0.06	9.50±0.64	1.76±0.25	8.27±0.67	1.72±0.09	10.47±0.87
91-120	1.29±0.11	6.59±0.70	1.28±0.08	7.06±0.54	1.35±0.19	9.84±1.19	1.67±0.12	10.59±0.69
121-150	1.74±0.84	6.25±1.25	1.61±0.18	7.64±0.53	2.03±0.34	8.25±1.01	1.69±0.13	9.98±0.66
151-180	1.50±0.27	6.00±0.65	1.39±0.19	8.61±0.59	1.82±0.33	7.85±0.56	1.73±0.14	9.52±0.67
181-210	1.36±0.23	5.00±0.81	1.54±0.24	7.12±0.47	1.28±0.25	8.62±1.47	1.64±0.12	8.25±0.54
211-240	1.04±0.16	4.16±0.33	1.80±0.44	6.50±0.64	1.39±0.17	6.95±1.05	1.81±0.14	8.13±0.47
241-270	1.20±0.17	4.62±0.71	1.32±0.21	6.00±0.50	1.12±0.04	6.00±1.38	1.39±0.07	8.48±0.42
271-300	1.12±0.22	2.85±0.49	1.25±0.19	3.33±0.88	1.33±0.20	8.21±1.10	1.37±0.72	9.12±0.62
301&above	1.09±0.09	6.33±0.60	1.11±0.08	6.34±0.77	1.20±0.13	7.42±0.60	1.64±0.16	8.18±0.64
Overall Av.	1.26±0.06	5.95±0.31	1.31±0.04	7.90±0.26	1.54±0.07	7.85±0.29	1.61±0.03	10.17±0.43
Level of Significance	NS	NS	NS	**	NS	NS	NS	*

NS= Not significant, * $p<0.05$, ** $p<0.01$; MY=milk yield, SCC= somatic cell count.

Table 2. Breedwise somatic cell counts ($\times 10^5$ cells/ml) and milk yield (kg) during different parity in winter season

Parity	Tharparkar		Sahiwal		Karan Swiss		Karan Fries	
	SCC	MY	SCC	MY	SCC	MY	SCC	MY
I	0.99±0.15	5.50±0.68	1.16±0.14	5.05±0.10	0.82±0.05	7.18±0.86	1.06±0.07	8.90±0.39
II	0.91±0.06	2.30±0.96	1.08±0.08	8.13±1.29	0.96±0.04	8.14±1.78	1.05±0.06	10.23±0.66
III	1.22±0.11	8.25±0.25	0.97±0.07	8.91±1.30	0.93±0.04	10.08±1.57	1.09±0.07	11.60±0.72
IV	0.94±0.27	8.66±3.16	1.05±0.10	11.71±1.31	1.04±0.08	10.00±1.46	1.28±0.11	14.71±1.36
V	1.12±0.32	9.25±3.58	1.14±0.24	9.10±2.78	1.07±0.03	10.00±3.68	1.20±0.14	14.53±1.97
VI & above	1.27±0.25	5.75±1.07	1.37±0.13	9.14±1.50	1.15±0.12	12.75±1.56	1.10±0.04	11.39±1.06
Overall Av.	1.10±0.10	6.39±0.82	1.12±0.05	8.48±0.62	0.98±0.15	9.63±0.72	1.11±0.03	11.27±0.38
N	25		43		36		213	
Range	0.56-2.55		0.56-2.15		0.60-2.20		0.56-3.88	
Level of Significance	NS	NS	*	NS	NS	NS	NS	**

N= number of observations, NS= Non significant; * $p<0.05$; ** $p<0.01$, MY=milk yield, SCC= somatic cell count.

Table 3. Breedwise somatic cell counts ($\times 10^5$ cells/ml) and milk yield (kg) during different parity in hot-dry season

Parity	Tharparkar		Sahiwal		Karan Swiss		Karan Fries	
	SCC	MY	SCC	MY	SCC	MY	SCC	MY
I	1.11±0.06	4.87±1.55	1.11±0.03	7.38±0.54	1.11±0.04	6.60±0.58	1.01±0.04	7.91±0.35
II	0.95±1.04	5.45±0.25	1.10±0.07	8.07±0.92	1.18±0.11	8.30±0.64	1.11±0.06	9.86±0.62
III	1.20±0.10	4.75±0.50	1.09±0.05	7.20±1.11	1.17±0.04	7.67±0.24	1.16±0.03	8.87±0.73
IV	1.08±0.18	6.50±0.17	1.05±0.04	8.75±0.77	1.10±0.04	6.60±0.88	1.39±0.05	11.16±1.48
V	0.96±0.03	7.33±1.25	1.04±0.14	6.23±0.65	1.04±0.03	6.90±0.89	1.44±0.12	10.14±1.37
VI & above	0.91±0.02	9.25±0.47	0.98±0.07	8.06±0.15	0.79±0.09	4.75±0.75	1.27±0.10	9.50±1.60
Overall Av.	1.04±0.03	6.22±0.54	1.06±0.03	7.72±0.30	1.10±0.03	7.00±0.30	1.15±0.03	917±0.32
N	15		45		30		59	
Range	0.86-1.26		0.75-1.39		0.71-1.62		0.77-1.77	
Level of Significance	NS	*	NS	NS	*	NS	**	NS

N= number of observations, NS= Non significant; * $p<0.05$; ** $p<0.01$, MY=milk yield, SCC= somatic cell count.

Table 4. Breedwise somatic cell counts ($\times 10^5$ cells/ml) and milk yield (kg) during different parity in hot-humid season

Parity	Tharparkar		Sahiwal		Karan Swiss		Karan Fries	
	SCC	MY	SCC	MY	SCC	MY	SCC	MY
I	1.25±0.29	4.00±0.40	1.39±0.12	5.60±0.54	2.20±0.26	5.14±0.48	2.08±0.02	7.75±0.33
II	1.32±0.21	7.50±0.50	1.70±0.26	7.14±0.61	2.79±0.15	7.21±0.66	2.34±0.11	9.01±0.64
III	1.03±0.01	45.00±0.01	1.63±0.07	5.38±0.66	2.42±0.22	6.61±0.70	2.32±0.10	9.29±0.60
IV	2.55±0.01	6.00±0.01	1.42±0.11	8.83±1.28	2.52±0.36	7.40±0.60	2.27±0.17	8.45±0.59
V	1.26±0.12	6.13±1.89	1.87±0.23	5.92±1.16	2.32±0.23	6.88±0.72	2.41±0.20	9.17±0.93
VI & above	1.58±0.19	7.07±0.79	1.74±0.17	8.92±1.11	2.73±0.24	7.00±1.02	2.73±0.24	9.45±0.75
Overall Av.	1.49±0.11	8.21±2.09	1.61±0.09	6.99±0.38	2.46±0.11	6.42±0.30	2.28±0.05	8.65±0.23
N	19		47		46		185	
Range	0.90-2.58		0.73-2.59		0.91-3.86		0.71-4.32	
Level of Significance	NS	**	NS	*	NS	NS	*	NS

N= number of observations, NS= Non significant; * $p<0.05$; ** $p<0.01$, MY=milk yield, SCC= somatic cell count.

higher during hot humid ($p<0.01$) and low during hot-dry and cold season, the respective values being 2.14, 1.11 and 1.10×10^5 cells/ml (figure 3). The SCC varied from 1.50 to 3.00×10^5 cells/ml in different breeds of cows during hot-humid while it fluctuated within the range of 0.50 to 2.0×10^5 cells/ml during winter and hot-dry seasons. During

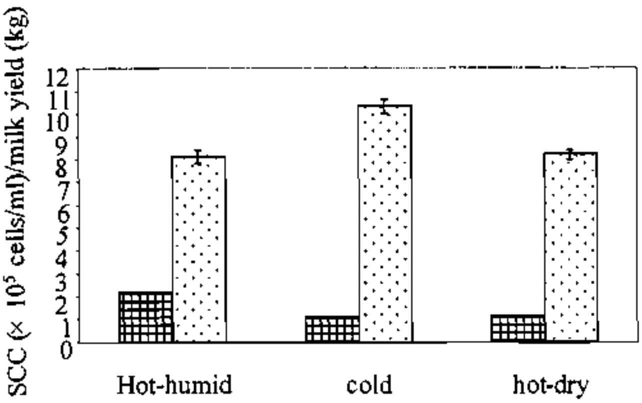

Figure 3. Somatic cell counts (▦) and milk yield (⊡) during different seasons in cows

hot–humid season, SCC was higher in all the breed of cows, but increases were more in the KS and KF cows than the Tharparkar and Sahiwal cows. Within the breed, the SCC changes during different season and parity were significant in KF cows and were non-significant in TP, SW and KS cows. During hot dry SCC varied in KS ($p<0.05$) and KF ($p<0.01$) cows without significant changes in milk yield. However, the SCC was not influenced by hot-dry in TP and SW cows while milk yields were significantly affected ($p<0.05$). The higher SCC during hot-humid season also indicated that both KS and KF breeds were under stress in comparison to TP and SW cows.

Correlation coefficients

In Tharparkar cows, the milk yield was not correlated either with SCC or parity and the stages of lactation. In Sahiwal cows milk yield was negatively correlated ($r=-0.261$; $p<0.01$) with parity only. Contrary to this, positive correlation's of milk yield with parity was found in KS ($r=0.294$; $p<0.01$) and KF cows ($r=0.232$; $p<0.01$). The SCC were negatively correlated with parity also in both the KS and KFcows ($r=-0.205$, $p<0.05$ and $r=-0.162$; $p<0.01$), respectively. The overall data indicated a negative correlation of the milk yield with SCC ($r=-0.096$, $p<0.05$). However, there was no definite pattern of the correlation of milk yield with the SCC during different stages of lactation.

DISCUSSION

The effect of stages of lactation on somatic cell count was not found significant because majority of the observations of SCC were in the broader range of 0.50 to 1.50×10^5 cells/ml during all the stages of lactation. It further suggests that once peak lactation is established, the number of SCC in milk gets stabilized and only minor alteration in somatic cell secretion occur. Further, the effect of stage of lactation, age and various stressors on SCC are minor, if mammary gland is not infected (Harmon, 1994). The high somatic cell counts observed in the present study during hot-humid climate might be due to the high humidity and ambient temperature (RH 85%, 38°C) as such conditions lead to stress in dairy cows (Dohoo and Meek, 1984, Hogan et al., 1989) and buffaloes (Singh and Ludri, 2001). Further, Randy et al. (1990) reported high values of SCC during hot-humid condition in cows due to more exposure of teat ends to pathogens and thus increase incidence of mastitis (upto 40%). Though SCC influenced by hot-dry condition in this study but high temperature does not affect milk production in KS and KF cows provided green fodder and water ad lib. during hot-dry season (Ludri and Singh, 1988). Low counts of somatic cells during cold season under the similar management conditions was reported earlier in buffaloes (Singh and Ludri, 2000). Stress being the most important factor determines the number of somatic cell counts in milk of cattle (Nelson et al., 1967). The high SCC during hot-dry season in all breed of cows was similar to the positive relationship between the stress of high summer environmental temperature and high SCC in milk of cows (Nelson et al., 1969). Administration of oxytocin, corticotrophin and rBST increase SCC content of milk in cows (Paape et al., 1973, 1974; Wegner et al., 1976; Oldenbroek et al., 1993). Jyotsana and Singh (2001) reported that oxytocin administration (2.5 IU/ day i.m. for 5 days) during ealry lactation increase singnificantly lymphocyte number in buffaloes, however secretion of neutrophil, monocyte and cytoplasmic particles remain unaffected. Further, there was no effect of oxytocin on milk production, composition, pH, EC and NEFA concentration.

The non-significant effect of parity on the SCC indicated that with increasing number of lactation, secretion of SCC in milk does not change. However, some report in cows and goats indicate significant changes in SCC by parity and stages of lactation being high during 2nd than in later lactation's, high just after calving subsequent rapid decrease by day 30 of lactation while further increase towards the end of lactation (Randy et al., 1991; Muggli, 1995). However, basal values of SCC were more in KS and KF cows than the TP and SW. The negative correlation ($p<0.05$) of milk yield with somatic cell counts found in this study was also reported earlier in cows (Raubertas and Shook, 1982; Fetrow et al., 1988; Fox et al., 1985) and buffaloes (Singh and Ludri, 2001), might be due either to the dilution of SCC by increased milk production or variations of somatic cell with change of milk yield (Miller et al., 1991). The SCC recorded in this study were higher than those of buffaloes under similar set of management condition which suggested that cows are more prone to the ambient temperature and humidity leading to more udder stress and also prone to mastitis (Harmon, 1994;

Anonymous, 1984). The values of SCC observed in all four breed of cows were lower than those reported earlier in exotic cows during different parity, season and stages of lactation (Hanns and Suchanek, 1991; Suniyasathaporen et al., 2000). Geneurova et al. (1993) also reported significant effect of breed on somatic cell counts.

CONCLUSION

It can be concluded from the present study that SCC in milk is not influenced by stages of lactation and parity in Zebu and crossbred cows. However, season especially the hot-humid condition has a significant effect on secretion of somatic cell in milk. Further, under the similar set of management condition the somatic cells are secreted more in KS and KF cows than the Tharparkar and Sahiwal cows.

REFERENCES

Anonymous. 1984 Annual Report. National Dairy Research Institute, Karnal, Haryana.

Das, M. and Mahendra Singh. 2000. Variation in blood leucocytes, somatic cell count, yield and composition of milk of crossbred goats. Small Rumin. Res. 35:169-174.

Dohoo, I. R. and A. H. Meek.1984. Somatic cell counts in bovine milk. Can. Vet. J. 23:119-124.

Dulin, A. M., M. J. Paape, W. D. Schultz and B. T. Weinland. 1983. Effect of parity, stage of lactation and intramammary infection on concentration of somatic cells and cytoplasmic particles in goat milk. J. Dairy Sci. 66:2426-2433.

Fetrow, J., K. Anderson, S. Sexton and K. Butcher. 1988. Herd composite somatic cell counts: Average linear score and weighted average somatic cell count score and milk production. J. Dairy Sci., 71:257-260.

Fox, L. K., G. E. Shook and L, H, Schulz. 1985. Factors related to milk loss in quarters with low somatic cell counts. J. Dairy Sci. 68:2100-2107.

Geneurova, V., O. Hanns, B. Gabriel and I. Zvackova. 1993. Somatic cell counts of milk in relation to production factors. Zivocisna Vyroba, 38:359-367.

Haenlein, G. F. W. and L. S. Hinckley. 1995. Goat milk somatic cell counts situation in USA. Int. J. Anim. Sci. 10:305-310.

Hanns, O. and B. Suchanek. 1991. Variability and somatic cell counts in cows milk as influenced by some internal and external factors. Zivocisna Vyroba. 36:303-311.

Harmon, R. J. 1994. Physiology of mastitis and factors affecting somatic cell counts. J. Dairy Sci. 77:2103-2112.

Hogan, J. S., K. L. Smith, K. H. Hoblet, D. A. Todhunter, P. S. Schoenberger, W. D. Hueston, D. E. Pritchard, G. L. Bowman, L. E. Heider, B. L. Brockett and H. R. Conrad. 1989. Bacterial counts in bedding materials used in nine commercial dairies. J. Dairy Sci.72:250-258.

Jyotsana and Mahendra Singh. 2001. Somatic cell counts in milk of buffaloes administered oxytocin during early lactation. Asian-Aust. J. Anim. Sci. 14 (5):684-692.

Lin, C. J. and H. S. chang. 1994. Studies on the relationship between somatic cell counts and milk quality in goat. J. Chinese Soc. Anim. Sci. 23:407-418.

Ludri, R. S. and Mahendra Singh 1988. Efficiency of milk production in crossbred cows during summer and winter seasons. International J. Anim. Sci. 4:52-55.

Marecus, E. K. Jr. and E. S. Dale. 1994. Factors affecting milk somatic cells and their role in health of the bovine mammary gland. J. Dairy Sci.77:619-627.

Miller, R. H., M. J. Paape and L. A. Fulton. 1991. Variation in milk somatic cells of heifers at first calving. J. Dairy Sci. 74:3782-3790.

Muggli, J. 1995. Influence of somatic cell counts on stage of lactation. Anim. Breed. Abstr. 1996.

Nelson, F. E., J. D. Schuh and G. H. Scott. 1967. Influence of season on leucocytes in milk. J. Dairy Sci. 50:978(Abstr.).

Nelson, F. E., H. Tranmal, J. D. Schuh, T. N. Wegner and G. H. Scott. 1969. Criteria of abnormal milk from individual quarters during a period of high temperatures. J. Dairy Sci. 52:912 (Abstr.).

Oldenbrock, J. K., G. J. Garssen, L. J. Jonker and J. D. Wilkinson. 1993. Effect of treatment of dairy cows with recombinant bovine somatotropin over three or four lactations. J. Dairy Sci. 76:453-467.

Paape, M. J., W. D. Schultze and R. H. Miller. 1973. Leukocytic response to adrenocorticotrophic hormone as influenced by the infectious history of the mammary gland. J. Dairy Sci. 56:84.

Paape, M. J., W. S. Schultze, R. H. Miller and J. W. Smith. 1973. Thermal stress and circulating erythrocytes, leucocytes and milk somatic cells. J. Dairy Sci. 56:84.

Paape, M. J., D. W. Carroll, A. J. Kral, R. H. Miller and C. J. Desjardins. 1974. Corticosteroids, circulating leucocytes and erythrocytes in cattle: Diurnal changes and effects of bacteriologic status, stage of lactation and milk yield on response to adrenocorticotropin. Amer. J. Vet. Res. 35:355.

Randy, H. A., W. A. Caler and K. I. Murray. 1990. Management practices of New York and Vermont DHI herds with low somatic cell counts. J. Dairy Sci. 73(Suppl.1):278.

Randy, H. A., W. A. Caler and W. H. Miner. 1991. Effect of lactation number, year and milking management practices on milk yield and SCC of French Alpine dairy goats. J. Dairy Sci. 74 (Suppl.1):311-315.

Raubertas, R. F. and G. E. Shook. 1982. Relationship between lactation measures of somatic cell concentration and milk yield. J. Dairy Sci. 65:419-425.

Sheldrake, R. F., R. J. T. Hoare and G. D. McGregor. 1983. Lactation stage, parity, and infection affecting somatic cells, electrical conductivity, and serum albumin in milk. J. Dairy Sci. 66:542-547.

Silva, L. D. and K. F .S. T. Silva. 1994. Total and differential cell cunts in buffaloes (*Bubalus bubalis*) milk. Buffalo J. 2:133-137.

Singh, Mahendra and R. S. Ludri. 2000. Somatic cell counts (SCC) in Milk of buffaloes. Proc. National Seminar on Sustainable Development of Buffaloes for Milk, Meat and Draft held at NDRI, Karnal from Oct., 14-16. p. 17(Abstr.).

Singh, Mahendra and R. S. Ludri. 2001. Somatic cell count in Murrah buffaloes (*Bubalus bubalis*) during different stages of lactation, parity and season. Asian-Austr. J. Anim. Sci. 14:189-192.

Singh, Mahendra, A. K. Dang and Jyotsana Prasad. 2001. SCC-An essential index for quality control of milk and health of udder. Indian Dairyman. 53(6):45-48.

Suriyasathaporn, W., Y. H. Schukken, M. Nielen and A. Brand. 2000. Low somatic cell count: a risk factor for subsequent clinical mastitis in a dairy herd. J. Dairy Sci. 83:1248-1255.

Snedecor, G. W. and W. G. Cochran. 1980. Statistical methods. 7th Edn., Iowa State Univ. Press, Ames, Iowa. Page

Wegner, T. N., J. D. Schuh, F. E. Nelson and G. H. Stott. 1976. Effect of stress on blood leucocyte and milk somatic cell counts in dairy cows. J. Dairy Sci. 54:949-956.

Wilson, D. J. K. N. Stewart and P. M. Sears.1985. Effect of stage of lactation, production, parity and season on somatic cell count in infected and uninfected dairy goats. Small Rumin. Res., 16:165-169.

Wilson, R. J. 1994. Physiology of mastitis and factors affecting somatic cell counts. J. Dairy Sci. 77:2103-2112.

Wilson, D. J., K. N. Stewart and P. M. Sears. 1993. Factors affecting somatic cell counts in dairy goats. Proc. 32nd National Mastitis Council Annual Meeting, Kansas City, MO, P-210.