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Short Paper

Monitoring udder health status using somatic cell counts in Holstein dairy herds located in north-east of Iran and effectiveness of 10-point mastitis control program

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Abstract

Background: The somatic cell count (SCC) of individual cow samples is a useful proxy for monitoring udder health status. **Aims:** The present study aimed to provide updated information about udder health in Iranian Holstein dairy cattle, and to quantify the effectiveness of the mastitis control program. **Methods:** A total of 17,990 monthly test-day records from 1,663 Holstein dairy cattle in 10 "regular" herds and 2,389 test-day records from 386 Holstein dairy cattle in 2 herds that were assigned to the 10-point mastitis control program ("controlled" herds) were included. Each test-day record comprised the date of recording, daily milk production (kg), fat and protein (%), days in milk, parity, and SCC. **Results:** Median (Q1-Q3) SCC $\times 10^3$ for "regular" and "controlled" herds were 136 (52-391) and 64 (24-204) cells/ml, respectively. Also, the percentage of records containing SCC >200,000 cells/ml (elevated SCC) for these groups were 40.3% and 25.5%, respectively. Mixed effects logistic analysis revealed that milk records from cows in the first lactation, early lactation, and with >40 kg daily milk yield had lower odds of elevated SCC. The odds of elevated SCC were lower in summer and autumn than in winter. **Conclusion:** Host and environmental characteristics influence SCC. This should be considered for the interpretation of SCC results. Mastitis control programs can support dairy producers to reach a standard level of udder health.

Key words: Dairy cow, Iran, Mastitis control program, Somatic cell count, Udder health

Introduction

Monitoring milk somatic cell count (SCC) is a useful and well-established method to identify subclinical mastitis (SCM) and track udder health at individual and herd levels. This information is useful for treatment decision-making and the consultation process in dairy farms (Hawkins, 2019). The most commonly used cut-off value for SCM in individual cattle is 200,000 cells/ml, which has an acceptable sensitivity and specificity (Blowey and Edmondson, 2010; Constable *et al.*, 2016). SCM is associated with decreased milk production, quality, and inadequate milk processing. For every 100,000 SCC increase over 200,000, there will be a 2.5% reduction in daily milk yield (Blowey and Edmondson, 2010), resulting in over 363 kg milk production loss per cow/305 days (Bradley and Green, 2005). Furthermore, most dairy companies penalize farmers with bulk tank SCC above 200,000 cells/ml, and producers with SCC >400,000 cells/ml are not permitted to sell their milk, e.g. in the European Union (Blowey and Edmondson, 2010).

There are approximately 13,200 commercial dairy herds housing a total of 2,090,000 dairy cows in Iran. The average milk yield per cow per lactation is 10,100 kg. About 90% of milk production is utilized in the country, and the surplus of milk and milk products is exported (Statistical Centre of Iran, 2017). Controlling SCM can help dairy farmers to produce more milk with higher quality. More than one decade ago, the average SCC in Iranian dairy farms was reported to be >400,000 cells/ml (Bolourchi *et al.*, 2008). We conducted the present study to provide updated information on the udder health in commercial Holstein dairy herds in the north-east of Iran. The prevalence of test-day records with elevated SCC (>200,000 cells/ml) was determined and the association of host and environmental factors with the probability of elevated SCC was investigated. Furthermore, to quantify the effectiveness of a precise mastitis control program, we analysed SCC records of dairy cows assigned to the 10-point mastitis control program.

Materials and Methods

Study population and data collection

This study was conducted in north-east of Iran. The climate in this area is characterized by a hot and dry summer (average minimum and maximum temperature 17-34°C) and a mild and humid winter (2-12°C). Precipitation in summer is rare and in winter is about 80 mm (Iran Meteorological Organization, 2018). Participating dairy herds were registered at "the Centre of Animal Breeding and Promotion of Animal Products, Iran", and farmers agreed to take part in the study. Monthly test-day records were retrieved from 10 herds located in north-east Iran between 20 March 2017 and 20 September 2018. All records were checked for plausibility and errors, and data from cows ≤7 and >300 days in milk (DIM) and animals with clinical diseases were excluded. From these 10 herds ("regular" herds), 17,990 monthly test-day records from 1,663 Holstein dairy cows were analysed. The median herd size was 180 milking cows (range 110 to 500 cows), mean (±SD) parity was 2.5 ± 1.5, and the average 305-day milk production ranged from 9,500 to 11,400 litres. Each test-day record included the date, daily milk (kg), fat and protein (%), DIM, parity, and SCC ($\times 10^3$ cells/ml), determined using Fossomatic 5000 (Foss Electric, Hillerød, Denmark). Parity was coded as categorical variable (primiparous and multiparous cows), mean daily milk yield as a categorical variable with three classes: <30 L, 30-40 litres, and >40 L, and season as a categorical variable with four classes: spring (March to May), summer (June to August), autumn (September to November), and winter (December to February). DIM was categorized as 1st (8-30 DIM), 2nd, 3rd (31-90 DIM), and ≥4th months of lactation (91-300 DIM).

Within the same period, we recorded the SCC of 2,389 monthly test-day records of 386 Holstein dairy cattle from two herds that were assigned to the 10-point mastitis control program (Constable *et al*., 2016) under expert's supervision ("controlled" herds). The mean (±SD) parity was 2.9 ± 1.7, the average 305-day milk production was 10,500 and 12,100 L/cow for the two "controlled" herds. In these herds, pre-milking and post-milking teat disinfection were performed using chloride and an iodine based dip, respectively. Teats were dried with a single service paper towel. A blind dry cow therapy was performed for all cows. Clinical mastitis cases were treated with non-steroidal anti-inflammatory drugs (NSAIDs), and locally or systemically with antibiotics, chosen based on herd data for the likely causative agent and the antibiotic resistance pattern. The inclusion criteria for the enrolment of test-day records in "controlled" herds were similar to the test-day records of "regular" herds.

Milk samples were drawn by the Centre of Animal Breeding and Promotion of Animal Products, Iran as part of routine monitoring procedures with informed owner consent. Therefore, the study was exempt from ethical approval according to the Iran regulations.

Statistical analysis

All analyses were carried out using Stata Statistical Software, release 12.0 (Stata Corporation, College Station, TX, USA). Crude SCC, natural logarithm (ln) SCC, and somatic cell score (SCS) were described as medians [first quartile (Q1) - third quartile (Q3)]. SCS was calculated using the equation: SCS= ln [(SCC/100,000)/0.693]+3 (Constable *et al*., 2016).

The percentage of records containing >200,000 cells/ml was compared between "regular" and "controlled" herds using the Chi-square test. The association between each explanatory variables, including parity, DIM, milk yield at recording date (host characteristics) and recording season (environmental characteristic), and the chance of elevated SCC (SCC >200,000 cells/ml) as a dependent variable were evaluated by univariate Chi-square tests. Explanatory variables associated with a chance of an elevated SCC at P<0.20 were selected for inclusion in the multivariate analysis. We used a mixed effect logistic regression model to quantify the effect of the prescribed explanatory variables on SCC as a binary outcome (0 = less than or equal to 200,000 cells/ml, 1 = greater than 200,000 cells/ml). Herds and cows within them were included as the random effects in the mixed effect logistic regression model to take into account the correlation between observations within a herd and the effect of repeated observations at the individual cow levels. Fat and protein (%) were compared between the elevated and non-elevated SCC records using a Mann-Whitney U test.

Results

In the "regular" herds, the medians (Q1-Q3) for SCC $\times 10^3$, ln SCC and SCS were 136 (52-391), 4.91 (3.95-5.97) and 3 (2-5). In total, 7,244 (40.3%) test-day records showed elevated SCCs (>200,000 cells/ml). The proportions of records containing elevated SCC ranged from 30.3 to 66.2% (Fig. 1).

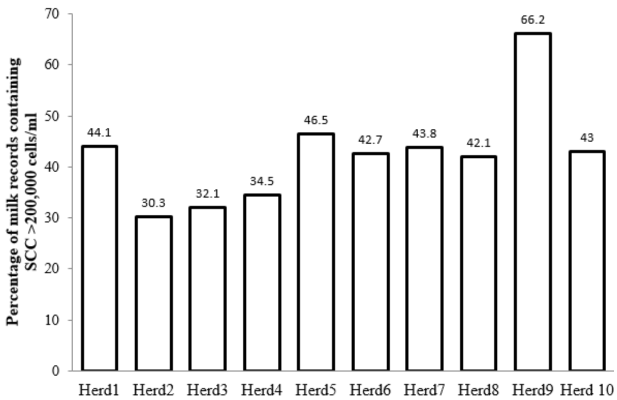

Fig. 1: Frequency of elevated SCC (SCC >200,000 cells/ml) records in "regular" dairy herds (n=17,990 test-day records from 10 herds)

A description of SCC in "regular" herds with regard

Table 1: Median somatic cell count (SCC) and frequency of elevated SCC (>200,000 cells/ml) with regard to parity, milk yield, stage of lactation, and season (n=17,990 test-day records from 10 "regular" herds)

Explanatory variables	Levels	Number of tested records	SCC×10^3 cells/ml Median (Q_1;Q_3)	SCC >200,000 cells/ml		P-value[a]
				n	%	
Parity	Primiparous	6,030	77 (35;215)	1,584	26.3	<0.001
	Multiparous	11,958	183 (71;479)	5,660	47.3	
Milk yield (kg)	<30	3,984	206 (75;594)	2,022	50.8	<0.001
	30-40	6,886	127 (49;381)	2,690	39.1	
	>40	7,120	117 (46;313)	2,534	35.6	
Stage of lactation	1st month	1,602	105 (46;301)	542	33.8	<0.001
	2nd and 3rd months	4,044	110 (41;364)	1,483	36.7	
	≥4th months	12,344	149 (58;408)	5,221	42.3	
Season	Spring	6,049	146 (56;431)	2,559	42.3	<0.001
	Summer	5,354	125 (47;348)	2,033	38.0	
	Autumn	3,204	136 (53;387)	1,263	39.4	
	Winter	3,383	139 (53;402)	1,391	41.1	

Q1: First quartile, and Q3: Third quartile. [a] P-values show the association of each explanatory variable and chance of elevated SCC records by the univariate Chi-square test

Table 2: Mixed effect logistic regression model showing the odds of the record containing elevated somatic cell count (>200,000 cells/ml) in Holstein dairy cows (n=17,990 test-day records from 10 "regular" herds)

Independent variables	Levels	B	SE	P-value	OR	95% confidence interval for OR	
						Lower bound	Upper bound
Parity	Primiparous	-1.08	0.06	<0.001	0.34	0.30	0.38
	Multiparous	Ref			1		
Milk yield (kg)	<30	0.88	0.06	<0.001	2.42	2.15	2.72
	30-40	0.39	0.05	<0.001	1.47	1.34	1.62
	>40	Ref			1		
Stage of lactation	1st month	-0.41	0.07	<0.001	0.67	0.58	0.76
	2nd and 3rd months	-0.10	0.05	0.030	0.90	0.82	0.99
	≥4month	Ref			1		
Season	Spring	0.06	0.05	0.304	1.06	0.95	1.17
	Summer	-0.22	0.06	<0.001	0.81	0.72	0.90
	Autumn	-0.17	0.06	0.005	0.84	0.75	0.95
	Winter	Ref			1		

B: Regression coefficient, SE: Standard error, and OR: Odds ratio

to parity, DIM, milk yield, and season, and the results of the univariate Chi-square test are shown in Table 1. These explanatory variables showed significant associations with the odds of elevated SCC and were included in the mixed effect logistic regression model. On average, the odds of elevated SCC test-day records was lower for primiparous than for multiparous cows (P<0.001). Milk records at 8-30 DIM (P<0.001) and 31-90 DIM (P=0.03) showed lower odds of elevated SCCs than those taken at 91-300 DIM. The test-day milk yields of <30 kg and 30-40 kg showed greater odds of elevated SCCs than >40 kg milk yield records (P<0.001). Furthermore, milk records taken during summer (P<0.001) and autumn (P=0.005) showed lower chance of elevated SCCs than those taken during winter (Table 2). Median (Q1-Q3) fat percentages were 3.0% (2.63-3.46%) and 2.95% (2.56-3.39%), and protein percentages were 2.93% (2.67-3.30%) and 2.87% (2.62-3.21%) for elevated and non-elevated SCC records, respectively (P<0.001).

The test day records from the two "controlled" herds revealed medians (Q1-Q3) for SCC × 10^3, ln SCC and SCS of 64 (24-204), 4.19 (3.18-5.31) and 2 (1-4), respectively, and 609 (25.5%) of the records with SCC

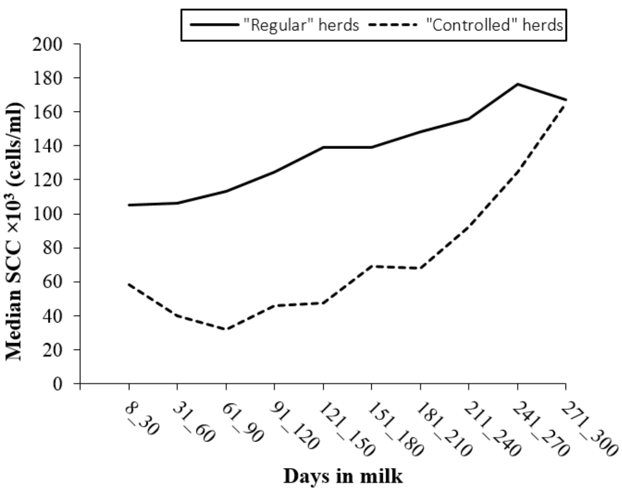

Fig. 2: Pattern of median SCC for test-day records from 10 "regular" and 2 "controlled" herds during 10 months of postpartum lactation

>200,000 cells/ml.

The proportion of elevated SCC test-day records in "controlled" herds was significantly lower than that of "regular" herds from the 1st to the 9th month of lactation (P<0.01) but not for the 10th month. The patterns of SCC variation during 10 months of lactation for the "regular" and "controlled" herds are presented in Fig. 2.

Discussion

The results of the present study provide updated information on SCC, although they cannot be regarded as representative for all commercial dairy herds in Iran. The median SCC was lower than 400,000 (Bolourchi *et al.*, 2008) and 250,000 cells/ml (Sadeghi-Sefidmazgi and Rayatdoost-Baghal, 2014), reported earlier for Iranian Holstein dairy herds. These findings may indicate improvements in the last years. The present study and other recent Iranian studies (Chegini *et al.*, 2017; Kheirabadi, 2018), however, show that several herds (40.3% of test-day records in "regular" herds with SCC >200,000) do not meet the targets for the dairy farm (80 to 85% of test-day records with SCC <200,000 cells/ml; Bradley and Green, 2005; Constable *et al.*, 2016).

In the present study, SCC in the two "controlled" herds were on average 55,000 cells/ml lower than in "regular" herds, and only 25.5% of test-day records had elevated SCC. Even though performing a precise mastitis control program is costly, increased milk yield and quality would be a strong stimulus for dairy farmers.

Higher odds of elevated SCC in multiparous cows may be explained by an increased probability of infection and a higher prevalence of permanent glandular damage from resolved infections compared to primiparae (Saravanan *et al.*, 2015; Hiitio *et al.*, 2017). A higher probability of elevated SCC in lower or medium yielding cows (<40 kg/d) is in line with reports that showed an association with SCC and reduced milk yield (Hand *et al.*, 2012; Goncalves *et al.*, 2018a). On the other hand, increasing milk yield may have a dilution effect on SCC (Green *et al.*, 2006) and, thus, masks SCM.

In accordance with a previous studies (Laevens *et al.*, 1997; Sharma *et al.*, 2011; Kern *et al.*, 2018), SCC was lowest during the first 2 months of lactation, and gradually increased over the rest of lactation. The decreased dilution effect after 3-4 months of lactation, repeated exposure to milking equipment, and the increased chance of infection can explain the increased SCC later in lactation (Harmon, 1994). Although a higher SCC has been reported during warmer seasons (Zucali *et al.*, 2011), we found lower proportions of elevated SCCs in summer and autumn than in winter. As described, the study region has a mild and humid winter. The difference in the climate of geographical regions and lower sanitary measures in winter may be reasons for differences in the growth of environmental bacteria in the bedding material of housed stocks, resulting in a contradictory effect of season on SCC.

Fat and protein percentages increased in cows with elevated SCC, which is in accordance with other investigations (Atasever and Stadnik, 2015; Chegini *et al.*, 2017; Goncalves *et al.*, 2018b).

This study provides information about SCC profiles, host and environmental factors influencing SCC, and effects of a mastitis control program on udder health in commercial dairy herds under semi-arid climate condition. Host and environmental characteristics should be considered for the interpretation of SCC results at individual and herd levels. Our findings suggest that mastitis control programs can help dairy producers to reach the standard milk quality.

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Conflict of interest

The authors declare that they have no conflict of interest.

References

Atasever, S and Stadnik, L (2015). Factors affecting daily milk yield, fat and protein percentage, and somatic cell count in primiparous Holstein cows. Indian J. Anim. Res., 49: 313-316.

Blowey, RW and Edmondson, P (2010). *Mastitis control in dairy herds*. 2nd Edn., Cambridge, CAB International. PP: 152-170.

Bolourchi, M; Mokhber, DM; Kasravi, R; Moghimi, EA and Hovareshti, P (2008). An estimation of national average of milk somatic cell count and production losses due to subclinical mastitis in commercial dairy herds in Iran. J. Vet. Res., 63: 263-266.

Bradley, A and Green, M (2005). Use and interpretation of somatic cell count data in dairy cows. In Pract., 27: 310-315.

Chegini, A; Hossein-Zadeh, NG; Hosseini-Moghadam, H and Shadparvar, AA (2017). Effect of somatic cell count on milk fat and protein in different parities and stages of lactation in Holstein cows. Acta Agric. Slov., 110: 37-45.

Constable, PD; Hinchcliff, KW; Done, SH and Grünberg, W (2016). *Veterinary medicine: A textbook of the diseases of cattle, horses, sheep, pigs and goats*. 11th Edn., China, Elsevier Health Sciences. PP: 1912-1970.

Goncalves, JL; Cue, RI; Botaro, BG; Horst, JA; Valloto, AA and Santos, MV (2018a). Milk losses associated with somatic cell counts by parity and stage of lactation. J. Dairy Sci., 101: 4357-4366.

Goncalves, JL; Kamphuis, C; Martins, CMMR; Barreiro, JR; Tomazi, T; Gameiro, AH; Hogeveen, H and dos Santos, MV (2018b). Bovine subclinical mastitis reduces milk yield and economic return. Livest. Sci., 210: 25-32.

Green, L; Schukken, Y and Green, M (2006). On distinguishing cause and consequence: Do high somatic cell counts lead to lower milk yield or does high milk yield lead to lower somatic cell count? Prev. Vet. Med., 76: 74-89.

Hand, KJ; Godkin, A and Kelton, DF (2012). Milk production and somatic cell counts: A cow-level analysis. J.

Dairy Sci., 95: 1358-1362.
Harmon, RJ (1994). Physiology of mastitis and factors affecting somatic cell counts. J. Dairy Sci., 77: 2103-2112.
Hawkins, D (2019). Use of different somatic cell count cut-points to define intramammary infection at drying off in dairy cows from a herd with a high somatic cell count. NZ Vet. J., 67: 203-209.
Hiitio, H; Vakkamaki, J; Simojoki, H; Autio, T; Junnila, J; Pelkonen, S and Pyorala, S (2017). Prevalence of subclinical mastitis in Finnish dairy cows: changes during recent decades and impact of cow and herd factors. Acta Vet. Scand., 59: 1-14.
Huijps, K; Lam, TJ and Hogeveen, H (2008). Costs of mastitis: facts and perception. J. Dairy Res., 75: 113-120.
Kern, EL; Cobuci, JA; Neto, JB and dos Santos Daltro, D (2019). Relationship between somatic cell score and longevity of Holstein cows in Brazil using a piecewise Weibull proportional-hazard model. Anim. Prod. Sci., 59: 1546-1552.
Kheirabadi, K (2018). Bayesian analysis of random regression models to model test-day somatic cell score of primiparous Holstein cattle in Iran. J. Appl. Anim. Res., 46: 677-684.
Laevens, H; Deluyker, H; Schukken, YH; De Meulemeester, L; Vandermeersch, R; De Muelenaere, E and De Kruif, A (1997). Influence of parity and stage of lactation on the somatic cell count in bacteriologically negative dairy cows. J. Dairy Sci., 80: 3219-3226.
Sadeghi-Sefidmazgi, A and Rayatdoost-Baghal, F (2014). Effects of herd management practices on somatic cell counts in an arid climate. Rev. Bras. Zootec., 43: 499-504.
Saravanan, R; Das, DN; De, S and Panneerselvam, S (2015). Effect of season and parity on somatic cell count across zebu and crossbred cattle population. Indian J. Anim. Res., 49: 383-387.
Sharma, N; Singh, N and Bhadwal, M (2011). Relationship of somatic cell count and mastitis: An overview. Asian-Australas. J. Anim. Sci., 24: 429-438.
Zucali, M; Bava, L; Tamburini, A; Brasca, M; Vanoni, L and Sandrucci, A (2011). Effects of season, milking routine and cow cleanliness on bacterial and somatic cell counts of bulk tank milk. J. Dairy Res., 78: 436-441.