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The effect of year, month, region, and herd size on bulk tank somatic cell and standard plate count, and the determination of optimum herd size in the intensive Holstein Friesian dairy farms in the Turkish Republic of Cyprus

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Abstract: The objective of this study was to determine the effects of mount, year, region, and herd size on the bulk tank somatic cell count (SCC) and standard plate count (SPC) and total milk production of Holstein Friesian cows and to decide for optimum herd size in Northern Cyprus. The total number of cattle was 64,450 heads and the number of enterprises was 168 in 2016. The milk samples were collected once or twice a month from each herd. SCC and SPC were determined with the Fluoro-opto-electronic counter method. Herd sizes were described from small to extra-large enterprises for Northern Cyprus conditions and six groups were created. The least squares means were compared among the herd size, region, month, and year for the data set. From 2012 to 2016, there was a significant amount (39.49%) of increase in milk production. While the total share of the enterprises which sold chilled milk was 22.36–28.82% in 2012–2016, the chilled milk production corresponded to 71.7–79% of all the dairy market. Bulk tank SCC numbers were found to be significantly higher in herds smaller than 40 and larger than 200 heads ($P < 0.05$). In the medium-sized enterprises (40–150 heads, Groups 2, 3, and 4), the number of bulk tank SCC was below the threshold level (400,000 cells/mL). The number of bulk tank SPC was found to be significantly higher in flocks with <40 heads and 150–199 heads ($P < 0.05$). Months had a significant fixed effect on the amount of bulk tank SCC ($P < 0.01$) and the highest and the lowest SCC amount was found in August, September, and December, respectively. However, the effect on the SPC was found insignificant. The average SCC continued to decrease every year (2012–2016). The SCC values for 2016 were found to be statistically more significant than all the other years. The SPC values displayed a scattered pattern over the years. The weakest regions were the Geçitkale and Güzelyurt regions.

Key words: Bulk tank somatic cell count, bulk tank standard plate count, Northern Cyprus, herd size, heat stress, Holstein cattle

1. Introduction

The major income from dairy cows is derived from milk. Therefore, the factors that reduce milk quantity and quality can cause high economic losses to farmers. In Northern Cyprus, which is characterized as a semiarid subtropical area, large-scale Holstein Friesian cow herds have extended to increase production and reduce the cost per unit of milk in the last 15 years, mainly as a result of spreading fixed costs across more production. Milk production generally decreases following the expansion of a dairy herd, but the preexpansion levels are reached or exceeded by the fourth year after the expansion [1,2]. Besides, there is no single herd size superior in all farms. This scale can change depending on the area, country, conditions, climate, profitability, and livestock policy. The production of quality raw milk depends on various factors such as season, herd size, region, breed, and management in intensive dairy farms, which determines the health of mammary glands and hygiene of the milk in dairy cows [3-7]. Milk quality has chemical and hygienic components. The chemical quality of raw milk is defined based on the fat and protein content, which is key for determining the potential use of milk in the industry. The hygienic quality is based on pollution levels and the distribution of specific microorganisms, which directly affects the shelf life of the product and consumer acceptance [8]. The hygienic quality of raw milk is defined by the somatic cell count (SCC) and the total bacterial count or standard plate count (SPC) present in milk tanks. The somatic cell count shows intramammary inflammation, which causes losses in milk production that may correspond to between 5% and 26% of the total production according to the degree of intensity of the inflammatory process and the stage of lactation [9,5]. SPC in bulk milk (BM) is a good indicator of milk hygiene at the dairy farm level during the phases of milking, storage, and transportation. At the farm level,

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the microbial contamination of bulk tank milk (BTM) shows 3 main sources: 1. Bacterial contamination from the external surface of teats, 2. from the milking and storage equipment, and 3. from the somatic cell (SC) from within the udder [5,10]. Udder health programs are not only important for individual cows but also for the herds, in which the population levels have increased in the last 20 years [11]. The herd- and population-level monitoring programs help carry out veterinary herd health programs more properly on the regional or country scale. It is important to follow trends over time and interfere when the cell counts appear to increase above a given threshold. At the population level, since the introduction of a standard mastitis prevention program by Neave et al. [12], an enormous progress has been achieved in decreasing the prevalence of infection and also the average SCC in bulk milk in national milk production. Collectively, SPC and SCC for bulk tank milk are widely viewed as indicators of dairy farm sanitation and animal-handling practices and can be used by processors [7].

Monitoring SCC at the herd level requires longitudinal data over time. The prevalence of infection increases with mean bulk milk SCC, but this is not a tight relationship due to the lognormal nature of cow SCC. At the herd level, it is especially important to follow trends over time and interfere when the cell counts appear to increase above a given threshold. The bulk milk SCC of a herd is shown approximately 200,000 cells/mL, which is a standard deviation of approximately 35,000 cells/mL [11,13]. At the herd level, farms with high SCC levels more often have high SPC levels. This may show that subclinical mastitis cases (in the herd, the percentage of cows with BMSCC > 250,000 cells/mL) cause an increase in bulk milk bacteria count. However, if BMSCC is below 85% and there are cows with somatic cell counts of <250,000 or <200,000, there is no subclinical mastitis. The primary parameters currently used to analyze the situation of a herd in mastitis control program are: i) bulk milk somatic cell count, ii) the percentage of cows with SCC > 250,000 cells/mL per test day, iii) the percentage of cows with new infections, and iv) the culling rate because of mastitis [11,14,15]. Subclinical mastitis is always related to low milk production, changes in milk consistency (density), reduced possibility of adequate milk processing, low protein, and a high risk for milk hygiene, which may even contain pathogenic organisms. The estimates of the loss of milk yields per unit increase in SCC on the test day were 1 mg/day per 103 cells/mL [16]. Dürr et al. [17] reported that the daily milk loss per unit increase in the natural logarithm of test-day SCC varied from 0.5 to 2.1 mg according to breed, parity, and the stage of lactation (SCC in 103 cells/mL).

The population level of BMSCC and SPC is different from the cow level. The upper limit for bulk tank SCC is 750,000 cells/mL, the average standard plate counts are <100,000 cfu/mL and <300,000 cfu/mL for Grade A according to the Food and Drug Administration (USA). Each month, between 72% and 88% of the milk pool has SCC levels (SCC ≤ 400×10^3 cells/ mL) in compliance with the EU requirements. The SPC levels of bulk tank milk at 30 °C are accepted according to the EU requirements as ≤100,000 cfu/mL (Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004, Section: 9/1/3). The sustained delivery of high-quality dairy products depends on the production of raw bulk milk with minimal bacterial contamination and SCC. The knowledge of regional trends in milk quality can provide insight into how external factors influence milk quality and increase understanding about differences in milk quality throughout the world [18]. The objective of this study was to determine the effects of month, year, region, and the herd size on bulk tank SCC and SPC and the total milk production of Holstein Frisian cows and to decide for the optimum herd size in Northern Cyprus.

2. Materials and methods

2.1. Materials

The study was performed on all dairy Holstein Friesian farms in Northern Cyprus (34′33″ and 35′41″ N, 32′17″ and 35′35″ E; 330,384 ha). As a result of its geographic position, the northern part of Cyprus has an extreme Mediterranean climate, characterized by hot and dry summers and moderately cold winters, separated by short autumn and spring seasons. The hottest months are June, July, and August, but September is also pretty warm. Spring includes April and May, and autumn includes only October and is the shortest season in Northern Cyprus. Winter, on the other hand, lasts from November till March.

However, there is a significant climatic variation due to the mountain ranges of the island. The Beşparmak range receives around 550 mm of rain per year, whereas certain portions of the Lefkoşa plain, which has the biggest amount of animal production, have very low annual precipitation (300–350 mm) and very hot summers. The amount of rain increases towards the mountains, and the climate in the coastal areas, with lower temperature ranges and higher atmospheric humidity, is less extreme than in the land. The annual average sunny hours are approximately 251.2 per month, with a minimum of approximately 165 h in winter (5 to 6 h per day) and with a maximum in summer of 315 h (10–11 h per day). The average high temperature in winter is 15 °C and the average low temperature is 5 °C. In summer, the average high temperature is 40 °C whereas the average low temperature is 18 °C, with daily highs of up to 42 °C.

The Northern Cyprus cow breed is Holstein Frisian, and the total number of cattle was 64,450 heads according

to the 2016 data. The livestock production is a major contributor to the agricultural gross domestic product in Northern Cyprus. The amount of cattle production is the biggest production with 18% in the total agriculture production. There are 5 official regions in Northern Cyprus, but 8 areas were analyzed in this research because of the distribution of the cattle (Table 1).

In Northern Cyprus, all of the cow milk that is produced by dairy cattle enterprises is sold to the Milk Marketing Board. This sale is mandatory by law (Milk Marketing Board law, 1/1977, 14/1986, 26/2011, and 36/2016). All of the analyses of milk are made by the board. The milks that have been analyzed are sold to private or semigovernment cooperative's milk processing factories through the Milk Marketing Board. Dairy cattle enterprises cannot sell their milk to milk processing factories without giving their milk to the Milk Marketing Board. At the same time, the Free Milk Marketing Board was established in 2012. The producer can sell a maximum of 20% of the total milk production in the Milk Marketing Board. The price of the milk is paid to the producers according to the results of the analysis of milk quality and quantity. Between 2012 and 2016, on average, milk containing more than 1×10^6 somatic cells and bacteria count was fined 2.5% per liter.

All lactating cows are housed in free stalls in the open intensive system. As the feed is imported, it is in short supply. The source of roughage in Northern Cyprus is cereal hay/straws (barley, wheat, triticale, and lolium). In terms of the production area, the most important crop grown in the northern part of Cyprus is cereals (85,000 ha, 2007). The main cereal crop is barley, planted on about 93% of the cereal area, followed by wheat (6%) and oats (1%). All the protein sources for the total mix ration (soybean and sunflower) is imported by private companies and one government establishment called the Agricultural Product Board. The aridness has been a major problem for roughage source in Northern Cyprus for some years.

Underground water sources are insufficient and generally the degree of water hardness (conductivity) and the salinity content rate is really high (2500 ≥ ɱhos/cm). Therefore, dairy enterprises have to buy safe and clear water and this problem directly influences animal health and milk quality.

2.2. Method

2.2.1. Data

The milk samples were collected once or twice a month from each herd in Northern Cyprus by the Milk Marketing Board routinely from the bulk tank (homogenized, ⁺4 °C, two parallel samples, 25 mL for each sterile screw tube) and transferred (+4 °C) to the laboratory for analysis. All the analyses were performed within 24 h of the pickup time. SCC and SPC were determined with the Fluoro-opto-electronic counter method using a Fossomatic™ FC 5000 analyzer and the BactoScan FC equipment, respectively.

The data set was available for the number of enterprises and then the SCC and SPC analyses were performed for each enterprise depending on the herd size (>24-month-old cow for 2015–2016), year, region, and month from 2012 to 2016. The herd size was described as 1 (small), 2 (medium I), 3 (medium II), 4 (medium III), 5 (large), and 6 (extra-large) for the enterprises in Northern Cyprus conditions (Tables 2 and 3).

Table 1. The total number of cattle in Northern Cyprus between 2012 and 2016 and groups by age and region in 2015 and 2016[#].

Region	-2012	-2013	-2014	2015		2016	
				>24-month-old cows	Total	>24-month-old cows	Total
Gazimağusa				1542	2841	1730	3103
Geçitkale				2623	5234	2677	4961
Girne				1806	3278	2008	3761
Güzelyurt				3746	6308	4236	7346
*İskele				1967	3476	2094	3336
Lefkoşa				11,244	20,340	9526	16,956
Vadili				12,958	24,387	12,535	23,841
*Ziyamet				787	1456	709	1246
Total	54.581	65.419	64.644	**36,673	67,320	**35,515	64,550

[#]Northern Cyprus Ministry of Agriculture and Natural Source Statistics 2016

- There is no official data for >24-month-old cows in 2012, 2013, 2014.

*Ziyamet and Iskele regions have not been evaluated statistically due to the lack of the SCC and SPC analysis numbers.

**The number of cows older than 24 months in 2015 and 2016 is 55% of the total number of cattle.

Table 2. The total number of >24-month-old cows and the number of enterprises in herd size for >24-month-old cows.

Group	Herd size for >24-month-old cows (2015/2016)	The number of enterprises	The number of >24-month-old cows		
			Mean	Min	Max
1 (small)	<40	15	27	10	39
2 (medium 1)	40–69	19	58	44	69
3 (medium 2)	70–99	34	84	70	99
4 (medium 3)	100–149	52	125	100	149
5 (large)	150–199	24	168	150	192
6 (extra-large)	>200	24	289	202	550

Table 3. The number of enterprises by the year and SCC and SPC analysis numbers for only chilled milk (2012–2016).

		Years				
		2012	2013	2014	2015	2016
*Analysis numbers	Number of SCC	3 187	3 590	3 632	3 254	3 638
	Number of SPC	2 442	3 596	3 590	3 249	3 851
The number of enterprises delivering chilled milk		141	157	171	168	168

*After editing the data set comprising a total of 17,301 samples for SCC and 16,728 for SPC of minimum 141 and maximum 171 dairy enterprises between 2012 and 2016 were analyzed. Of the samples, 9013 samples for SCC and 8987 for SPC were used in statistical evaluation. The number of analysis with less than 3 monthly measurements within 1 year and number of dairy enterprises of region with less than 5 in 3 years were discarded.

2.2.2. Descriptive statistics

The data were analyzed using the general linear model procedure of the SAS. Least squares means were compared among the herd size, region, month, and year for the data set (significance levels of $P \leq 0.01$ and $P \leq 0.05$).

Somatic cell score and plate cell score logs were transformed to obtain the normal distribution [19]. The SCC and SPC threshold value in bulk milk was accepted as 400,000 cells/mL and 100,000 cfu/mL at the herd level, respectively. According to these standards, the SPC of raw milk is less than 100,000 cfu/mL and SCC is less than 400,000 cells/mL (Regulation (EC) of the European Parliament and the Council, No 853/2004 Official Journal of the European Union).

The data on chilled milk were used in the analyses.

The statistical model used for the analysis is as follows:

$$Y_{ijklm}=\mu + a_i + c_j + d_k + f_l + e_{ijklm} \quad (1)$$

Yijklm: log10 SCC, SPC is the observation of i^{th} herd size, j^{th} region, k^{th} year, l^{th} month,

μ: overall mean,

ai: i. the effect of the herd size (I = 1, 2 …. 6),

cj: j. the effect of the region (j = 1, 2, ……),

d_k: k. the effect of the year (k = 2012, 2013, …. 2016),

f_l: l. the effect of the month (l = January, February, ... December),

eijklm: random error.

3. Results

Table 4 shows the total amount of produced milk and the percentage of milk chilled/nonchilled in Northern Cyprus by years.

From 2012 till 2016, there was a significant amount (39.49%) of increase in the production of milk. While chilled milk constituted 71.7% of the milk that was produced in 2012, this rate increased to 79% in 2016 (Table 4). The percentage of the enterprises which delivered chilled milk increased to 48.15% from 2012 till 2016 (Table 5).

While the total share of the enterprises which sold chilled milk was between 22.36% and 28.82% in 2012–2016, the chilled milk production was between 71.7% and 79% of all the dairy market (Tables 4 and 5). In 2015, the number of the enterprises with the SCC amount below 400,000 cells/mL was 79 (48.2%). Meanwhile, in 2016 this figure was 85 (52.8%). The share of these enterprises in the total milk production was 50.8% and 57.6%, respectively.

In terms of bulk tank SCC, 70% of the 20 enterprises with the highest and lowest numbers of SCC in 2015 maintained their status in 2016. In terms of bulk tank SPC, 50% of the 20 enterprises with the lowest SPC in 2015 remained the same in 2016 as well. In terms of SCC and SPC, the correlation coefficient (Spearman's p) between the ranking values of the enterprises was calculated as 0.855 and 0.700, respectively, and was found statistically significant ($P < 0.01$).

Table 6 and Figure 1 present bulk tank somatic cells and plate numbers in chilled milk according to the herd size.

The numbers of bulk tank SCC were found to be significantly higher in herds smaller than 40 and larger than 200 heads ($P < 0.05$). In medium-sized enterprises (40–150 heads, Groups 2,3, and 4), the number of bulk tank SCC was below the threshold level (400,000 cells/mL). The ratio of these enterprises within the total enterprises was 61.14%. The large enterprises group is the same as the medium enterprises in terms of SCC. The extra-large group (>200) had significantly higher SCC numbers ($P < 0.05$). The best group was the medium I (40–69) group and its share among the total enterprises was 11.43%. However, the SCC count was above the threshold level of

Table 4. Total cow milk production (chilled milk and nonchilled milk) in Northern Cyprus.

Years	Chilled milk, ($\times 10^3$ kg)	Nonchilled milk, ($\times 10^3$ kg)	Total, ($\times 10^3$ kg)	Chilled milk in total milk %
2012	76,263.2	30,035.5	106.298.7	71.7
2013	87,982.5	30,637.3	118.619.8	74.2
2014	101,816.3	33,503.6	135.319.9	75.2
2015	107,753.7	32,074.1	139.827.8	77.1
2016	117,188.6	31,090.6	148.279.2	79

Table 5. The percentage of dairy cattle enterprises delivering chilled milk in all enterprises between 2012 and 2016.

The percentage of enterprises delivering chilled milk in all enterprises (%).				
2012	2013	2014	2015	2016
28.08	22.36	23.16	24.9	28.82

Table 6. SCC and SPC numbers according to the herd size.

		Somatic cell count (SCC) $\times 10^3$ cells/mL			Somatic plate count (SPC) $\times 10^3$ cfu/mL		
*Herd size	The number of enterprises	Number of analyses	*Mean	SE	Number of analyses	Mean	SE
<40	14	714	494,310.6[a]	0.0122	675	312,607.9[a]	0.0252
40–69	20	865	356,451.1[c]	0.0106	832	198,609.5[c]	0.0217
70–99	35	1866	365,594.7[c]	0.0082	1772	177,418.9[c]	0.0168
100–149	52	2918	378,442.5[c]	0.0075	2757	184,077.2[c]	0.0156
150–199	28	1333	375,837.4[c]	0.0096	1270	243,781.1[b]	0.0197
>200	26	1317	435,511.8[b]	0.0093	1250	183,231.4[c]	0.0191

*The data were back-transformed from $\log^{10}$ values after statistical analysis
SCC: Somatic cell count; SPC: Standard plate count
*Herd size: Number of the ≥24-month-old cows between 2015 and2016.
Values with different superscripts within a column differ significantly $P < 0.05$.

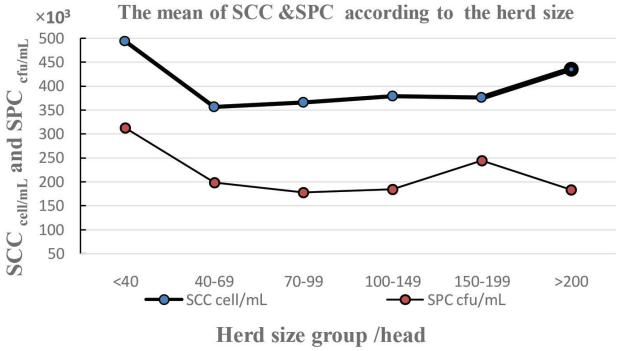

Figure 1. SCC and SPC numbers according to the herd size.

Table 7. Numbers of bulk tank milk SCC $_{cells/mL}$ and SPC $_{cfu/mL}$ according to the months from 2012 to 2016.

Month	Number of analysis	SCC × 10^3 cells/mL	Number of analysis	SPC × 10^3 cfu/mL
January	747	397.19 ^{bcd}	618	221,309.5^{a}
February	752	390.83 ^{cde}	624	211,836.1^{a}
March	753	435.62 ^{a}	621	215,278.2^{a}
April	692	432.51 ^{ab}	680	205,589.1^{a}
May	741	420.48 ^{ab}	700	221,309.5^{a}
June	774	413.66 ^{abc}	774	217,270.1^{a}
July	766	419.09 ^{abc}	766	222,331^{a}
August	680	440.27 ^{a}	668	**230,144.2^{a}
September	775	**443.12 ^{a}	773	210,862.8^{a}
October	778	419.39 ^{ab}	777	190,546.1^{a}
November	784	***350.67 ^{d}	784	***183,231.4^{a}
December	771	375.18 ^{de}	771	219,280.5^{a}

*The data were back-transformed from log^{10} values after analysis, **the highest value, ***the lowest value.
Values within a column with different superscripts differ significantly $P < 0.05$.
Average number of monthly analysis for SCC and SPC: n= 751.08 ± 33.29 and 713 ± 68.30 / month between 2012 and 2016.

250,000.000 cells/mL in terms of subclinical mastitis in all the operating sizes.

In terms of bulk tank SPC, the number of bulk tank SPC was found to be significantly higher in flocks with <40 heads and 150–199 (large group) heads ($P < 0.05$). No group has fallen below the threshold of 100,000 cfu/mL for SPC. In the medium-sized enterprises (40–150 heads, Groups 2,3, and 4), the bulk tank SPC number was below 200,000 cfu/mL and showed compatible values. This group included the extra-large group. The lowest bulk tank SPC level (177,418 cfu/mL) was found in the medium 2 group. It was the most successful group in terms of both SCC and SPC and milk quality.

Table 7 and Figure 2 present the effect of the numbers of bulk tank SCC cells/mL and SPC cfu/mL according to the months. Month has a significant fixed effect for bulk tank SCC amount ($P < 0.01$) and the highest and the lowest month was respectively August, September, and December, but it was not significant for SPC. In spite of this, the highest value of SPC was seen in August and the lowest in November. Both SCC and SPC values remained high in the hottest months. The value of SCC maintained its high level from March to November and remained above the threshold levels of 400,000 cells/mL. This is an indication that subclinical and clinical mastitis cases are seen at a high level throughout the country during the year. It falls below

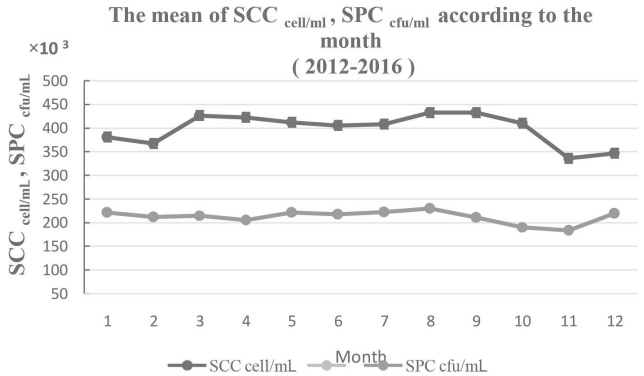

Figure 2. Means of bulk milk SCC (cells/mL) numbers according to the month from 2012 to 2016.

400,000 cells/mL only in November, December, January, and February, but never goes below the 250,000 cells/mL limit, which is accepted for subclinical mastitis.

It is thought that the 10th and 11th months of the SPC value, which are not statistically significant, are related to the decrease in milk amount in these months. However, farm management shows a poor performance in terms of milking hygiene and cold tank hygiene throughout the year. The SPC value never fell below the 100,000 cfu/mL threshold level in any month.

Between 2012 and 2016, in terms of months, the bulk tank SCC values were above the threshold value, which is 400,000,000 cells/mL, except for January, February, November, and December. However, the maximum value was 440,275,886 ± 0.01 and 443,121,171 ± 0.01 cells/mL in August and September, respectively. The minimum value was realized in November with 350,679,356 ± 0.01 cells/mL. The bulk tank SCC values were found to be significantly higher than the other months starting from March to November. The bulk tank SCC values decreased significantly from October to March. The reason for this is that the temperature and humidity begin to drop in Cyprus in October. The number of somatic cell count is above 250,000 cells/mL in all months.

The highest SCC average in terms of years (2012–2016) was 429,526,536 cells/mL in 2012 in milk samples collected and analyzed from all dairy farms in Northern Cyprus (Figure 3). In 2016, it decreased to 381,478,442 cells/mL. The SCC average continued to decrease every year (Figure 3). The country punishment average was above 400,000,000 cells/mL in 2016. The SCC values for 2016 were found to be statistically more significant than all the other years ($P < 0.01$). This shows that the farmers understand the importance of udder health and milk quality every passing year.

The SPC values displayed a scattered pattern over the years (Figure 3). The highest value belongs to 2016 with 212,813,905 cfu/mL ($P < 0.01$). The lowest value was 182,389,570 cfu/mL in 2013 ($P < 0.01$). This shows that farmers do not follow a sustainable and correct management in terms of milking hygiene and cooling tank hygiene.

When we look at the SCC cells/mL amounts by the region (Figure 4), the lowest value is 285,759,100 cells/mL ($P < 0.01$), (number of >24-month-old cows = 1730) in Gazimağusa, which has the least number of animals. The highest value is 522,396,000 ± 0.0115 cells/mL ($P < 0.01$) in the Geçitkale region. The Vadili (number of >24-month-old cows = 12,535) and Lefkoşa (number of >24-month-old cows = 16,956) regions, which have the largest number of animals and medium-sized enterprises, are below 400,000,000 cells/mL.

4. Discussion

The results of this study suggests that management deficiencies in mastitis control, and consequently increases in SCC, are likely to occur in small farms (<40 heads) and much larger farms (>200 heads) in Northern Cyprus ($P < 0.05$). It can be said that the medium-sized enterprises are more successful and sufficient in this regard.

An earlier study of Wisconsin dairy farms (USA) enrolled in a milk quality improvement program [7,20] found that the group means for SCC were 369,000 cells/mL for small farms (≤118 cows), 273,000 cells/mL for large farms (119–703 cows), and 240,000 cells/mL for extra-large farms (>714 cows). Although the categories of herd sizes are quite different from Northern Cyprus, in the Wisconsin scale, mastitis management has been reported to be less successful in small enterprises, but free stalls have been more successful in large enterprises.

The small herd size category (20 to 49; 435,760 cells/mL) had the highest SCC, with the category of large herd size (>450; 350,020 cells/mL) having the lowest values in the Holstein herd of North Carolina. However, medium herd sizes (50–249; 386,150–396,200 cells/mL) have more acceptable values compared to small herds size

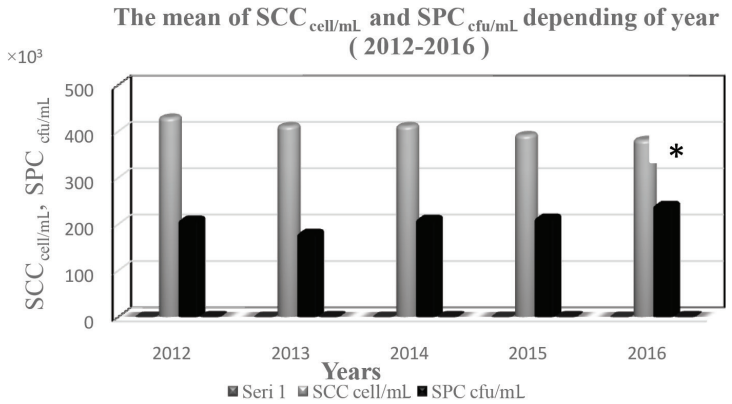

Figure 3. Bulk milk SCC numbers (cells/mL) according to the year, from 2012 to 2016. *SCC number decreased significantly in 2016 compared to the other years, P < 0.01.

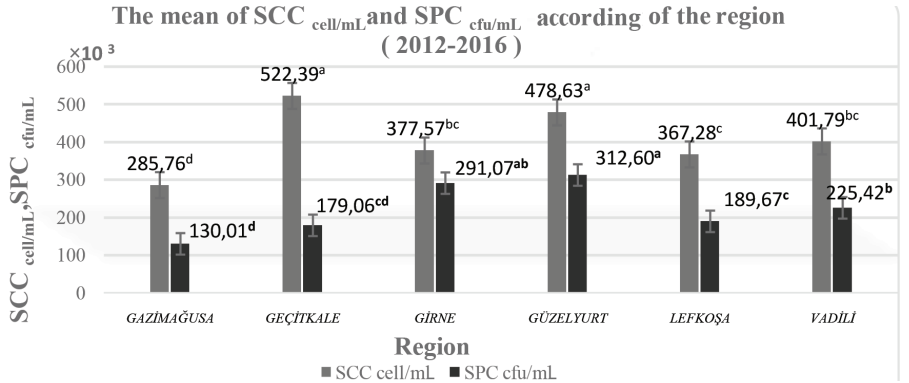

Figure 4.: Bulk milk SCC (cells/mL) numbers according to the region from 2012 to 2016. Values with different supercripts within a column differ significantly, P < 0.01

[3]. Larger farms had lower values of SCC and plate loop count bacteria/mL (PLC), but more antibiotic violations. However, larger farms contribute to most of the SCC and PLC of the total pool of milk [21]. The average herd size in Ireland is 58 cows, and 11.25% of farmers have herds with more than 100 cows. Facilities and management practices often differ based on herd size and have been associated with differences in bulk milk SCC [18]. In Ireland, across all months, herds that sold the least amount of milk (herd size 1) had the greatest total bacterial count (TBC) and SCC. Across all months, the differences in SCC were observed between herd sizes 1 (<36 heads) and 2 (36–56 heads), whereas the differences in TBC were observed in all months [18]. On the other hand, the most important reason why the number of SCC is higher in the large-sized (>200 heads) enterprises in Northern Cyprus compared to the medium-sized enterprises is the milking management practices, which are performed with inadequate and untrained labor. The same case applies to the small-sized enterprises (<40 heads).

In terms of bulk tank SPC, the number of bulk tank SPC was found to be significantly higher in the herds with less than 40 heads and 150–199 (large group) heads (P <0.05). In the medium-sized enterprises (40–150 heads, Groups 2, 3, and 4), the number of bulk tank SPC was below 200,000 cfu/mL and showed compatible values. The extra-large group (>200 heads) also joined this group. The lowest bulk tank SPC level (177,418 cfu/mL) was found in the medium II group. No group was below 100,000 cfu/mL. The SPC values of <100,000 are most likely caused by lapses in sanitation or inadequate refrigeration and transportation [7]. The number of SPC in dairy cattle enterprises in Northern Cyprus was above the threshold level of 100,000 cfu/mL in all sizes of herds, which shows that the enterprises were very insufficient in terms of udder pollution score, milking machine, equipment, cooling tank cleaning, sanitation, and hygiene.

In the study of small, large, and extra-large enterprises in Wisconsin (USA), the maximum SPC value of small farms was 250,000 cfu/mL, but the average was 58,700. The

SPC averages decreased as the business size increased [7]. In Northern Cyprus, the medium-sized enterprises and the extra-large group (40–150 heads, Groups 2, 3, and 4 and <200 heads) showed better values than the small and large enterprises.

The bulk tank SCC values higher than 400,000 cells/mL were encountered in the hottest and high humidity months (from March to October) in Northern Cyprus. In all months, the bulk tank SCC values were higher than 250,000,000 cells/mL. It may have been due to poor udder hygiene management and heat stress and its effects, and also the lack of knowledge about economic losses in subclinical mastitis in dairy cattle farms. Rhone et al. [22] found the highest SCC value in May (summer season: March–June in Thailand). When the temperature-humidity index was high (THI over 80), the number of somatic cells significantly increased more than the low THI (low THI: 190,000 cells/mL; high THI: 259,000, $P < 0.05$). At a high level of temperature-humidity index (THI), SCC had a negative significant correlation with the total milk yield [23]. SCC was higher in milk from Holstein dairy cows suffering from heat stress than dairy cows under comfortable conditions [24]. High-yielding lactating cows were mostly sensitive to thermal stress especially in hot environment [25]

Between 2012 and 2016, the number of bulk tank SCCs dropped significantly each year. The country average remained below ≥400.000 cells/mL in 2016. The most important reason was that the SCC threshold for penalty was set at 400,000 cells/mL during 2016. A previous study conducted in the Netherlands showed that farmers were more likely to respond to penalties (rather than bonuses) regarding the adoption of management measures aimed at improving udder health [26]. In a study conducted in Ireland, the number of SCC showed a similar situation between 2007 and 2011. For the combined data set, small differences ($P < 0.01$) in annual SCC were identified for all adjacent years. The annual mean SCC increased as of 2007 (259,000 cells/mL), peaked in 2009 (272,647 cells/mL), and then declined to 244,399 cells/mL in 2011 in Ireland [18].

In a study conducted in Serbia between 2006 and 2009 with 45,600 milk samples regardless of the size of the enterprises, the raw milk ratio was below SPC <100,000 cfu/mL in 2009 with a ratio of 31%. The ratio between 100,000 and 500,000 was 22.71% and ≥500,000 was 46.28% [27]. In Northern Cyprus, the SPC is well above the SPC < 100,000 limits in all years and in contrast to the SCC, it reached its highest (212,813,905 cfu/mL) value in 2016. An unstable situation has been observed over the years.

Since 2015, in Northern Cyprus, farms with SCC numbers higher than 600,000 cells/mL and SPC numbers higher than 400,000 cfu/mL have been warned by the Milking Marketing Board, and the warnings have continued by narrowing the border every year. After 01.01.2020, raw milk was classified in five different quality categories for SCC and 6 different categories for SPC and the penalty set up started for SCC ≥ 600.000 cells/mL and SPC ≥ 400,000 cfu/mL. To effectively manage bulk tank SCC, it is necessary to identify cows, farm quarters, and region with high SCC. Although milk recording identifies cows with problem, it is the subsequent actions of the farmer that have the ability to result in lower bulk SCC. Such actions include culture, segregation, treatment, or removal of infected cows from the herd [28].

It is reported that there is an increase in the number of SCC in the regions where the number of animals are high, but there are many variables that affect this situation [29]. The weakest region in terms of the incidence of mastitis is the Geçitkale region. The Güzelyurt region is the weakest region in terms of operational hygiene and management in terms of both SCC and SPC values ($P < 0.01$). It is important to evaluate these findings primarily in the mastitis prevention program in terms of regional solutions.

In conclusion, this study showed the general conditions of bulk tank SCC and SPC in all the milk that has been produced from Holstein Friesian breed cows in Northern Cyprus, which is a subtropical region. This study investigated the effect of herd sizes, years, regions, and months on the amounts of bulk tank SCC and SPC. In this context, it has been demonstrated that the medium-sized (40–150 heads) dairy cattle enterprises in Northern Cyprus are more efficient than the small and extra-large herds. Herds smaller than 40 heads do not provide suitable conditions for both bulk tank SCC and SPC; therefore, small (family) enterprises need to be supported within the framework of mastitis prevention program and the importance of milk hygiene with a special strategy. Also, it has been concluded that the herds of dairy cows that are larger than 200 heads are less suitable for Northern Cyprus. Due to the increased milk procurement policy and mastitis awareness, it has been observed that management and udder health have improved gradually over the years.

Since the region is subtropical, it has been proven that in summer months temperature stress affects Holstein cows, which causes SCC numbers to increase significantly. Although all the regions are equally affected by climate conditions, it has been observed that there are important differences between regions in terms of the amount of SCC and SPC. The reason for this difference is considered to be due to the lack of knowledge and insufficient labor about herd management and economic loss caused by mastitis. At the same time, a mastitis prevention program should be commenced and necessary cooling and nutritional measures should be taken to reduce heat stress in all cattle enterprises. In addition, the Holstein breed has been

significantly affected by heat stress, even though it has been thought to be adapted to the region. In this context, it is important to choose Holstein breeds which have heat tolerance to artificial insemination.

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