STUDY REGARDING THE INFLUENCE OF THE TEMPERATURE - HUMIDITY INDEX VALUE ON THE HEALTH OF THE MAMMARY GLAND IN A DAIRY COWS HERD FROM A FARM IN IAŞI COUNTY

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Abstract

The values of NSC registered in a herd of cows vary depending on environmental factors such as temperature and humidity which, through direct synergistic action on the animals, induces stress levels that influences the defense capacity of the immune system of animals. The data were statistically processed to analyze the influence of heat stress on the mammary gland health in a herd of dairy cows. The highest values of the SCC average were recorded in autumn of 229.020 x 10^3 cells/ml and in summer of 220.870 x 10^3 cells/ml. As a result of the study, we can conclude that heat stress (THI ≥ 66) can be one of the factors that influence the health of the mammary gland.

Key words: *THI, SCC, Holstein, heat stress*

INTRODUCTION

Cattle are animals that, having sweat glands, withstand high temperatures more easily compared to other species if relative humidity is low, dissipating excessive heat through sweat. The rate of heat loss by an organism is greatly influenced by the humidity of the environment for evaporation to occur through the skin and through respiration. Cows cannot get rid of excess energy through evaporation (sweating or breathing) in the same way as when the air is drier. Thus, problems with this species occur during hot summers with increased relative air humidity, when the natural ability of cows to thermoregulate the body through sweating and panting is compromised, the body temperature rises above the physiological level, which results in thermal stress of the animals [1]. The thermoregulatory process of the body is critical for survival, productive and reproductive performance as well as animal welfare being affected [2] with implications regarding the economic efficiency of their growth, regarding about the possible expenses imposed by maintaining the health of the animals.

As a result of other studies, either negative (milk production, feed intake, free thyroxine) or positive (breathing rate, heart rate, rectal temperature and cortisol level) correlations were established between THI values and some parameters [3;4;5].

In dairy cows, reductions in milk production of 17-53% and feed intake of 35-48% have been found due to heat stress. Low fertility was also registered, with artificial insemination (AI) conception rates ranging from 55% to less than 10% in months with high temperatures and high relative humidity. The most affected by thermal stress are the cows with the highest productions because they have a higher metabolic status, having to release the energy produced by the billions of microorganisms in the rumen. Breeding cows towards increased milk production – trait positively correlated with increased metabolic heat production, probably

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affected the thermoregulatory capacity of this category with potential reduction in their ability to cope with heat stress [6;7].

A number of indicators are used to estimate the degree of heat stress experienced by animals, the most widely used being the temperature-humidity index (THI) which incorporates the effects of both temperature and relative humidity and is commonly used to define a threshold that causes the onset of thermal stress. [1;8]. Because temperature alone cannot be used as an indicator of heat stress risk in cows, how humid or dry the air is also taken into account when the temperature is outside the comfort zone of the animal, air humidity becomes a significant element in maintaining the homeostasis of the body.

The consequences due to thermal stress become evident for THI values ≥ 70, for those above 78 milk production becomes seriously affected and when the value level THI=82 is exceeded, significant losses of milk production are likely to be observed, cows will show severe signs of stress, with the risk of them eventually dying. Alert threshold values (THI = 78) occur at 31 ºC and 40% relative humidity or only at 27 ºC and 80% relative humidity [9].

Heat stress can cause a 10% decrease in milk production at 27-32 ºC and 50-90% humidity, and even greater than 25% at a temperature of 32-38 ºC with 50-90% humidity, the effects being more pronounced in higher producing cows.

The area taken in study, Dancu, Holboca, pertain to an area with a temperate - continental climate, the maximum average monthly temperature being reached in July and the minimum in January. The annual amount of precipitation is moderate (550 mm) with a wet transition between spring and summer and an overlapping dry interval between late summer and early autumn [10].

MATERIAL AND METHOD

The indicators used in this study are: temperature and humidity in the external environment and the number of somatic cells/ml milk. The statistical estimators that characterize a normal distribution were calculated, such as the mean but also the dispersion indices represented by the variance and the standard deviation. For this purpose, the following computer programs were used: SAVC (Statistics Analysis of Variance and Covariance) respectively SPSS 16.00 for Windows. Estimators are written in Latin letters: arithmetic mean ($\bar{X}$), variance (s^2), standard deviation (s), and parameters with Greek letters: theoretical average (μ), variance (ó2) and standard deviation (ó) [11;12].

To calculate the THI value, which indicates the level of thermal stress of cattle following the action of the two mentioned factors (temperature and humidity), the following calculation formula was applied [9]: THI = (1,8 × T + 32) – (0,55 – 0,0055 × RH) × (1,8 × T – 26) where

-T - air temperature in ºC,

-RH - relative humidity (%) (air saturation at a certain temperature).

The study was carried out on a herd of 428 Holstein lactating dairy cows with different parity and in different stages of lactation. The animals are reared in an intensive system being maintained in free permanent stables, in closed shelters with individual resting areas and rubber mat bedding. The cows are fed throughout the year with a single ration with ad libitum access to water. On the farm, milking is automatic and is carried out twice a day in a fishbone milking parlor.

The collection of primary data for the period August - December 2022 and January - July 2023 was carried out:

- monthly mean values for air temperature and humidity were obtained from the Weather Underground online platform [13;14].
- the somatic cell count (SCC) was recorded monthly in the bulletins within the official performance control (OPC).

In order to highlight the influence of the level of heat stress on udder health, the data related to the number of somatic cells were grouped according to the levels considered for the other indicators:

- for THI: 35-44, 45-54, 55-64 and > 65.
- parity of cows;
- the 12 months of the year.

RESULTS

The average temperature values over the last ten years increased from year to year from 10.42 ºC for 2013-2014 period to 11.62 ºC in present. (table 1). The largest difference in averages is in case of mean of Winter, so last winter (2022-2023) was on 2.62 ºC warmer than 2013-2014 winter, from -0.4 °C to 2.22 °C last winter.

Table 1. The average values of the maximum and minimum temperatures of the period aug 2013- jul 2023

Indicator	Season	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023
average temperatures ºC		10,42	11,42	12,46	10,59	11,4	11,1	12,35	11,35	11,24	11,62
average max temperatures ºC		15,56	15,75	16,93	15,08	16,13	15,82	17,53	15,87	16,25	16,14
average min temperature ºC		6,89	6,45	7,51	5,9	6,91	6,64	7,4	7,03	6,34	7,32
Average temperatures per season ºC	summer	21,52	23,37	22,58	22,03	21,97	22,19	22,73	21,49	22,74	22,93
	autumn	11,82	10,91	12,39	10,65	11,72	11,03	12,89	13,02	10,63	11,41
	winter	-0,4	0,34	1,68	-1,72	0,06	-0,47	2,85	0,75	1,84	2,22
	spring	9,02	11,57	12,58	11,48	11,97	11,54	11,31	9,22	10,34	10,57

The warmest months of the period considered (2023-2024) were July and August (figure 1) with a value of monthly mean of 23.42 °C respectively 22.92 °C.

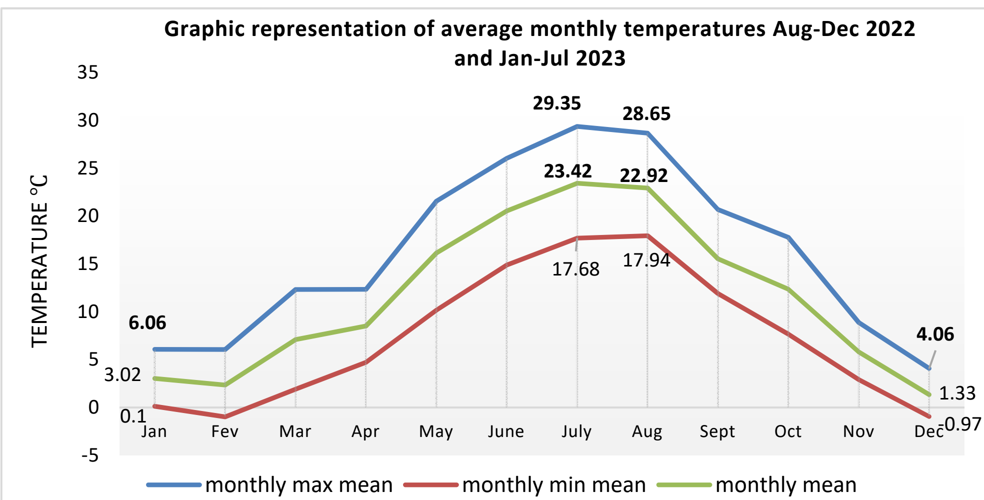

Figure 1. Graphic representation of monthly mean temperature and maximum and minimum monthly means of period

Table 2. Average monthly values of temperatures, humidity and THI for the period 2022 - 2023

Current number	Indicator	2023							2022				
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	T_m (ºC)	3,02	2,32	7,08	8,5	16,13	20,53	23,42	22,92	15,53	12,34	5,79	1,33
2	U_m (%)	87,44	73,29	63,48	80,42	60,18	63,39	63,84	69,52	72,03	71,15	89,11	92,26
3	THI_m	38,7	39,22	47,32	48,17	60,23	66,59	70,77	70,52	60,36	54,82	44,64	35,48

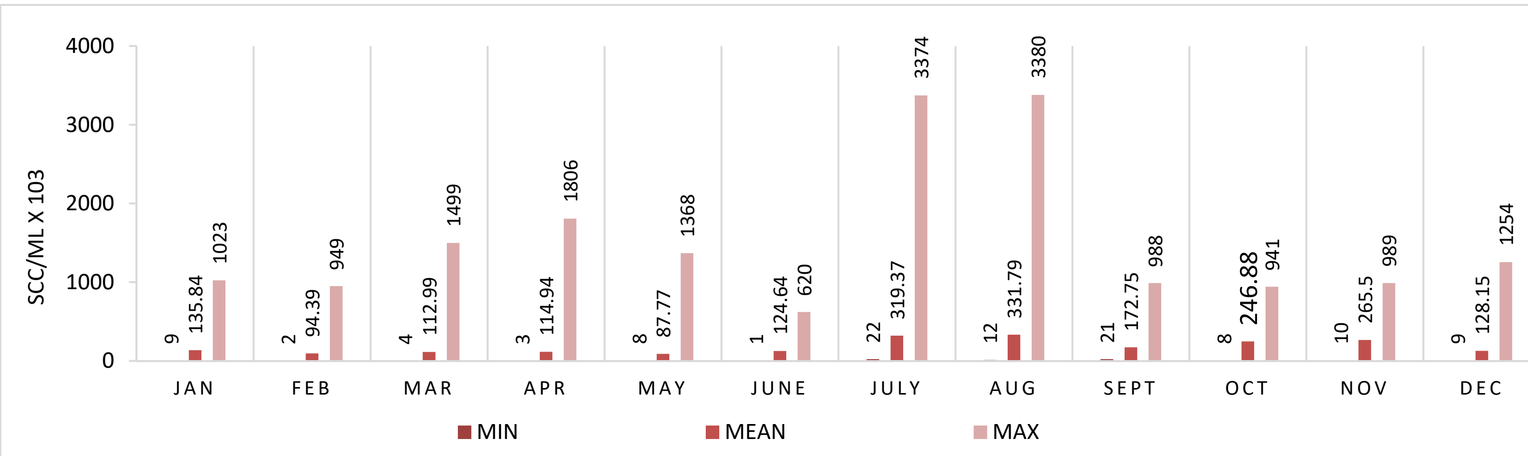

Figure 2. Graphic representation of monthly averages of SCC/ml x10^3

From average values structured in table 2 we conclude that the months with higher humidity are in winter and autumn (> 70 %) and values of THI are increased in June, July and august (> 65) which are the warmer and drier months also.

From the graphic representation of the figure 2 it can be concluded that the highest average values for SCC are in August and in July, and then in November and October. Average values of SCC are increased most often in August and July and in case of cows with multiple parturitions (figure 3).

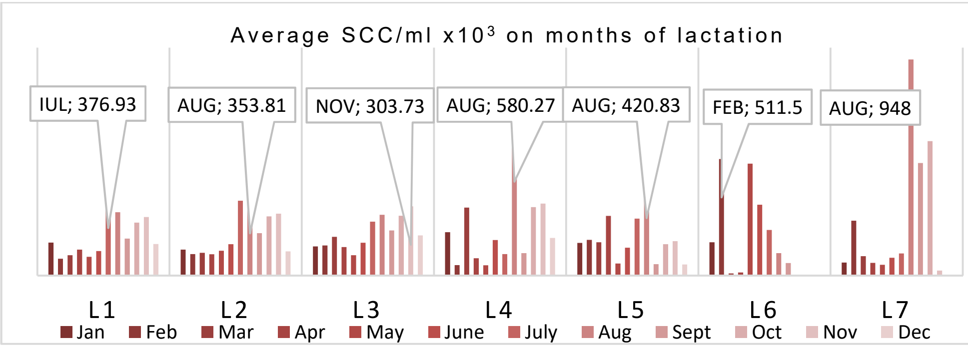

Figure 3. Graphic representation of the dynamics of SCC/ml x 10^3 by months of lactation

Table 3. Statistical estimators for SCC/ml x10^3 by season and mean values correlation

Seasons	**n**	$\overline{X}$	**±s** $_{\bar{x}}$	**s**	**V%**	Summer	Autumn	*p*-value
Spring	865	104.73	5.94	174.715	166.825	**	**	<0.01
Summer	568	220.87	17.079	407.05	184.295	-	*	<0.01
Autumn	840	229.02	9.184	266.184	116.226	*	-	<0.01
Winter	877	119.76	4.959	146.854	122.627	**	**	<0.01

* insignificant, **significant differences

In table 3 we can see that the average of SCC is increased in autumn and summer when values are 229,02 x10^3 respectively 220.87 x 10^3 cells/ml, almost double comparative with those in winter and spring.

In table 4 and figure 4 are presented the values of mean for SCC on THI intervals, noting that the highest averages are in the range 66-75 of the thermal stress index.

Table 4. Statistical estimators for SCC/ml x 10^3 by THI ranges and mean values correlation

THI	**n**	$\overline{X}$	**±s** $_{\bar{x}}$	**s**	**V%**	THI 66-75	*p*- value
35-45	1156	154.97	5.965	202.809	130.87	**	<0.01
46-55	859	157.81	7.741	226.871	143.759	**	<0.01
56-65	567	129.24	8.001	190.507	147.405	**	<0.01
66-75	806	257.25*	15.636	443.9	172.556	-	-

**significant differences

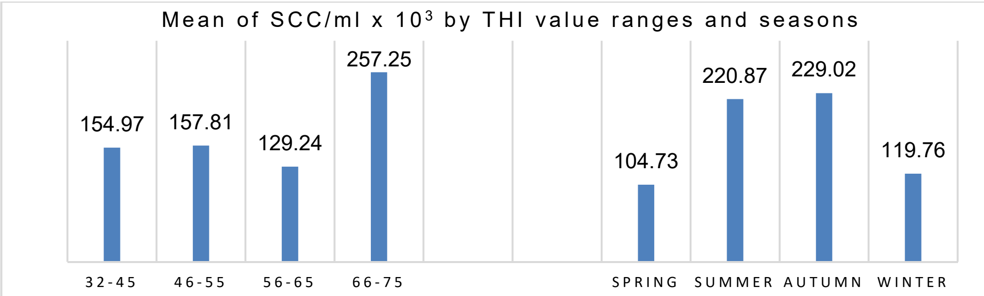

Figure 4. Graphic representation of mean values of SCC/ml x 10^3 by THI value ranges and season

DISCUSSIONS

Based on the temperatures recorded in the farm area it can be seen that in the last 10 years the annual average for the period has increased from 10.42 °C between 2013 - 2014 to 11.62 °C for 2022-2023. As can be seen in Table 1, during the decade the warmest period was 2019-2020 with an average daily maximum temperature of 17.53 °C and an annual average of 12.35 °C, recording increasing averages compared to the 2013-2014 period.

The highest temperature recorded was 37°C in August of 2015 and 2017. However, over the 10-year period, the warmest month was July with an average maximum temperature of 29.35 ⁰C and a monthly mean temperature of 23.42 °C. Under these conditions, the stressful effect of temperatures on the animals is obvious, especially since it is known that the superior limit of thermal comfort for dairy cows is at maximum of 20 °C.

In detail, for the period August - December 2022 and January - July 2023, Table 2 shows the average monthly values of temperatures and humidity, as well as the THI values calculated on their basis. The highest monthly averages are recorded in summer, in June, July and August, of 20.53°C, 23.42 °C and 22.92 °C.

The months with higher average humidity, over 70%, are the autumn and winter months and those with increased THI values are June with 66.59, July with 70.77 and August with 70.52.

Primary data providing information on somatic cell counts were obtained from the analysis results of the milk samples collected within the official performance control (OPC). Regardless of the criteria for grouping these data in the statistical analysis, the coefficient of variability values is very high, meaning that the samples are very heterogeneous. Because, by performing analysis of variance and Fisher test, in all statistical analyzes were obtained calculated values greater than the 5% threshold, for months of the year, seasons and THI intervals, it is shown that there are very significant differences between the samples.

Figure 2 shows the distribution of SCC average values per month for the analyzed years, noting that the monthly average values fall within the superior limit allowed. The highest averages are in the months with high THI values of 70.52 and 70.77, respectively August with 331.790 x 10^3 and July with 319.370 x 10^3 cells/ml, followed by November and October with an average of 265,5 respectively 246.880 x 10^3 cells/ml. Conducted studies confirm the significant increase of 450x 10^3 cells/ml SCC under heat stress conditions from spring to summer. [15;16]

High THI is associated with higher SCC which was increased with advanced parities cows also [17;18].

The influence of THI spreads over time, in the months following of its action. This is due to the response of the immune system on heat stress action, which makes the body vulnerable to the action of pathogenic factors. So, SCC also reflects a cow's immune response to general stress situations [8].

From the analysis of the SCC average values presented graphically in Figure 3, by months of lactation, we can conclude that the highest averages are found during the summer, the case of August. The fourth lactation is the one that records the highest value of the average, of 580.270 x 10^3 cells/ml, considering that the productive maximum is achieved. In the case of the third lactation, although in August the average is 266.66 x 10^3 cells/ml, in November the level is 303.73 x 10^3 cells/ml increased under the influence of heat stress effect over the summer and some factors that are not analyzed in this study (the feed ration, the stable degree of hygiene, the hygiene of milking, the proliferation of pathogenic agents etc.). For the 6th and 7th lactations, the number of cows is reduced and then the recorded values are analyzed individually.

The number of somatic cells is dynamic and seasonal. Analyzing the values of the estimators in table 3 and figure 4, it can be noticed that the highest average of the SCC is recorded in the summer (June, July and August) period of 220.870 x 10^3 cells/ml and in autumn (September, October, November) of 229.020 x 10^3 cells/ml. If during the summer the THI values are the highest (66.59, 70.77, respectively 70.52) the same does not happen in autumn, the increased value of the average being due to the effect that thermal stress has on the dairy cows, but also the competition of some factors different from it.

A final analysis considers different ranges of THI to analyze SCC levels, with the values of the statistical estimators presented in Table 4 and plotted in Figure 4. As expected, the highest average value for SCC is 257.250 x 10^3 cells/ml and characterizes the THI range of 66-75.

Following the covariance analysis, there were significant differences between the studied samples, with the THI= 65–75 range and all other value ranges considered, which had lower SCC values, being the most significant ($p<0.01$; CI=95%). Significant differences ($p<0.01$; CI=95%) are between SCC average values in winter compared to those in summer and autumn and also between the average values in spring and summer and autumn, in favor of spring and winter when values are lower.

CONCLUSIONS

Mastitis is one of the conditions that has multiple implications, economic and animal welfare. Based on the statistical analysis from this study we can conclude:

1) the most obvious dynamics of SCC average values is revealed by the statistical analysis by months of the year, when the highest average values are in the months of August and July of 331.790 and 319.370 x 10^3 cells/ml and then in November by 265.5 x 10^3 cells/ml, and in October by 246.880 x 10^3 cells/ml, which draws attention to the action and other factors that condition the health of the mammary gland in lactating cows;

2) the highest values of the SCC averages are in the 7th lactation of 249.900 x 10^3 cells/ml and in the 4th lactation of 197.150 x 10^3 cells/ml, during the summer, which is due to the age of the animals, the productive level and the effect of heat stress;

3) significant differences are found between the values in winter compared to those in summer and autumn, and also between the values in spring and summer and autumn, SCC in favor of winter and spring, the health of the mammary gland being determined in summer and autumn by the synergistic action of heat stress and other factors different from it;

4) the increased SCC averages values are during the summer and autumn and at THI values higher than 65, so, in the herd of cows studied, we can say that thermal stress influences the health of the mammary gland, which is also conditioned by the action of other factors related to by the rearing system and applied technology, the stable hygiene, milking hygiene, but also the protocol applied on the farm in the

treatment of sick animals are factors that contribute to an increased incidence of mastitis in the herd.

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