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The Effect of Breeding Region on Differences in Persistency of Heat Stress Effect in First Parity Simmentals

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Abstract

In order to determine the effect of breeding region on differences in persistency of heat stress effect in first parity Simmentals test-day records provided by the Croatian Agricultural Agency were analysed. Only cows with detected statistically significant decrease in daily milk yield at set temperature-humidity index (THI) threshold value (65, 70 and 75) were included in the further analyses. The persistency of heat stress effect regarding the daily milk traits was determined as a drop in the subsequent milk recordings (1st and 2nd). The research results indicate significant difference in animals' response to heat stress effect due to breeding region and individual's susceptibility to heat stress. The most pronounced and persistent negative effect of heat stress was determined in cows reared in Eastern region. Also, the negative effect of heat stress was more pronounced and more persistent in Simmentals that were heat stressed at the lower THI threshold values (cows that are more susceptible to heat stress).

Key words: heat stress, persistency, first parity Simmentals, daily milk traits, breeding region

Introduction

Currently, dairy cattle production is characterized by a growing demand for high animal production. Also, milk production takes place in an environment that changes to less favourable for dairy cows. According to Battista and Naylor (2009), by 2050, most of the world will be exposed to moderate temperatures during the summer, which will be higher than the highest recorded temperatures.

Furthermore, Gauly et al. (2013) warned that the heat stress of high-producing dairy cows will cause growing concern among European milk producers. Segnalini et al. (2013) emphasized the need for adequate adaptation of development strategies aiming at the reduction of negative effects of warming in farm animals in the Mediterranean region. In the European Union, GIRA (2012) predicts in the analysis of Regional movements in EU Milk Production that regions with intensive farming will be replaced by regions with less intensive farming around the Atlantic and with more land suitable for pasture (resulting in lower production costs). According to Hansen (2013), increased production makes cows more susceptible to heat stress, which means that the heat stress has become an acute problem regardless of climate change.

Modern dairy cows, which are characterized by high milk production, lose the ability to regulate their body temperature at air temperatures in the interval between 25 and 29 ^{o}C. The studies of Bohmanova (2006) and Collier et al. (2006) indicate that high-producing cows are affected by heat stress much more than low-producing ones. Kadzere et al. (2002) stated that the intensive genetic selection for milk production has changed the thermoregulation physiology of dairy cattle. High-producing cows have larger frames and larger gastrointestinal tracts that enable them to digest more feed, but this, on the other hand, creates more metabolic heat and reduces the ability of cows to regulate normal temperature at heat stress conditions. According to Kadzere et al. (2002), thermo-neutrality shifts to lower temperatures due to the increase of milk yield, feed intake and metabolic heat.

Due to heat stress the following are decreased in dairy cows: dry matter intake, milk production (West et al., 1999; Casa and Ravelo, 2003) and reproductive performances (Bohmanova et al., 2007; Ravagnolo et al. 2000). Additionally, heat stress affects milk composition, somatic cell counts (SCC) and mastitis prevalence (Bouraoui et al., 2002; Collier et al. 2012; Correa-Calderon et al., 2004; Gantner et al., 2017; Ravagnolo et al., 2000; St-Pierre et al., 2003; West, 2003; Hammami et al., 2013; Smith et al., 2013). Furthermore, the heat stress condition also leads to considerable loss of profit, e.g. between $897 million and $1,500 million per year in the USA (St-Pierre et al., 2003). There are many ways to measure heat stress although the temperature-humidity index (THI) is the most common measure used in dairy cattle breeding. THI includes ambient temperature and relative humidity and is a useful and simple method of assessing the risk of heat stress (Kibler, 1964).

The aim of this research was to determine the effect of breeding region (Eastern, Central and Mediterranean Croatia) on differences in persistency of heat stress effect in first parity Simmentals at different values of THI (65/ 70/ 75).

Material and Methods

Data. Individual test-day records of first parity Simmentals collected during regular milk recording performed by an alternative milk recording method (AT4/BT4) in the period from January 2005 to December 2012 in Croatia were used for statistical analysis. Milk yields were measured monthly at each recording, during the evening or morning milking. Additionally, at each milk recording, ambient temperature and relative humidity were recorded. Daily temperature-humidity index (THI) was calculated using the equation by Kibler (1964):

$$THI = 1.8 \times Ta - (1 - RH) \times (Ta - 14.3) + 32$$

where Ta is average temperature in degrees Celsius and RH is relative humidity as a fraction of the unit. Records with lactation stage in (< 6 days and > 305 days), age at first calving in (< 21 and > 36 months), missing parity, and missing or nonsense Ta and RH values were deleted from the dataset. Only cows with minimum 3 test days per lactation were taken into analysis. Data were provided by the Croatian Agricultural Agency.

Statistical analysis. The variation in daily milk traits due to heat stress was tested by least square analysis of variance for each given THI value (65, 70 and 75) separately for each region (Eastern, Central and Mediterranean Croatia) using the PROC MIXED procedure in SAS (SAS Institute Inc., 2000). The following mixed model was used:

$$y_{ijklmn} = \mu + b_1(d_i/305) + b_2(d_i/305)^2 + b_3\ln(305/d_i) + b_4\ln^2(305/d_i) + S_j + A_k + T_l + e_{ijklm}$$

where

y_{ijklm} = estimated daily milk trait;
μ= intercept;
b_1, b_2, b_3, b = regression coefficients;
d_i = days in milk (i= 6 to 305 days, lactation curve by Ali and Schaeffer, 1987);
S_j = fixed effect of calving season class j (j=1/2006 to 12/2012);
A_k = fixed effect of age at first calving class k (k=21 to 36 month);
T_i = fixed effect of THI class (l=0 (*normal condition – values under the given threshold*) or 1 (*heat stress condition – values equal and above the given threshold*));
e_{ijklm}= residual.

The significance of the differences between the THI classes was tested by t-test. Only cows with detected statistically significant decrease in daily milk yield were included in the further analyses. The daily milk trait measured on the recording day when heat stress occurred was used as the reference level. The drop in daily milk traits was determined in the 1st (test-day milk traits measured within 35 days) and 2nd (test-day milk traits measured between 35 and 70 days) milk recording after heat stress. The persistency of the effect of heat stress as a drop in daily milk traits was analyzed separately for each region (Eastern, Central and Mediterranean Croatia).

Results and Discussion

The effect of the breeding region (Eastern, Central and Mediterranean Croatia) on the amount of drop in daily milk traits in subsequent milk recordings (1st and 2nd) after detection of heat stress at different THI values (65, 70 and 75) is presented in Tables 1, 2 and 3.

The highest drop in daily milk yield in the 1st subsequent milk recording in the amount of 3.29 kg/day was determined in the first parity Simmental cows bred in the Eastern region of Croatia. The drop in daily milk yield in the 2nd subsequent milk recording was even higher amounting 3.52 kg/day. The lowest drop in the amount of 2.42 kg/day and 2.96 kg/day, in the 1st and 2nd subsequent milk control, respectively, was determined in Simmentals bred in the Mediterranean region. The drop in daily milk contents (fat and protein) determined in the subsequent milk recordings showed higher drop in fat than protein contents.

Tab. 1. Drop in daily milk traits in the subsequent milk recordings after detection of heat stress based on the breeding region (Eastern, Central and Mediterranean Croatia) at THI ≥ 65

Region	1st milk recording after heat stress			2nd milk recording after heat stress		
	DMY, kg	DFC, %	DPC, %	DMY, kg	DFC, %	DPC, %
Eastern	3.29	0.16	0.01	3.52	0.17	0.01
Central	3.08	0.09	0.02	4.15	0.15	0.02
Mediterranean	2.42	0.11	-0.03	2.96	0.19	-0.01

*DMY – daily milk yield, kg; DFC – daily fat content, %; DPC – daily protein content, %

The animals that experienced statistically significant ($P < 0.05$) decrease of daily milk yield at higher values of THI (≥ 70, Table 2; ≥ 75, Table 3) had lower drop of daily milk yield in the 1st subsequent milk recording comparing to animals stressed at lower THI value (≥ 65).

Similarly, in all cows, the drop in daily milk yield was higher in the 2nd subsequent milk recording comparing to the 1st one.

Tab. 2. Drop in daily milk traits in the subsequent milk recordings after detection of heat stress based on the breeding region (Eastern, Central and Mediterranean Croatia) at THI ≥ 70

Region	1st milk recording after heat stress			2nd milk recording after heat stress		
	DMY, kg	DFC, %	DPC, %	DMY, kg	DFC, %	DPC, %
Eastern	3.09	0.16	0.05	4.24	0.20	0.05
Central	2.77	0.11	0.03	3.47	0.19	0.05
Mediterranean	2.31	0.11	-0.01	3.24	0.21	0.03

*DMY – daily milk yield, kg; DFC – daily fat content, %; DPC – daily protein content, %

The analysis of the drop in daily milk contents, fat and protein showed a higher drop in daily fat than protein contents. Also, the drop in daily fat contents was higher in the 2nd comparing to the 1st subsequent milk recording.

Tab. 3. Drop in daily milk traits in the subsequent milk recordings after detection of heat stress based on the breeding region (Eastern, Central and Mediterranean Croatia) at THI ≥ 75

Region	1st milk recording after heat stress			2nd milk recording after heat stress		
	DMY, kg	DFC, %	DPC, %	DMY, kg	DFC, %	DPC, %
Eastern	2.66	0.18	0.08	3.91	0.25	0.10
Central	2.51	0.12	0.04	3.31	0.22	0.08
Mediterranean	3.09	-0.06	-0.12	3.99	0.05	-0.01

*DMY – daily milk yield, kg; DFC – daily fat content, %; DPC – daily protein content, %

According to a number of researches (Kadzere et al. 2002, Bohmanova 2006, Collier et al. 2006, Gantner et al. 2017, Hansen 2013), the THI threshold values depend on a variety of factors, such as production level, parity, breed, and region. According to Du Preez et al. (1990a, b), heat stress affects milk production and feed intake when THI values exceed 72. Bouraoui et al. (2002) set the threshold at 69, while Bernabucci et al. (2010) and Collier et al. (2012) set it at 68. Vitali et al. (2009) warned of the increased risk of cow death when THI = 80.

The results of this analysis showed that the lower the THI threshold value (65/ 70/ 75), the higher is the drop in daily milk yield in subsequent milk recordings. Also, the highest drop of daily milk yield in first parity Simmentals was determined in Eastern Croatia with a tendency of drop increase in the 2nd subsequent milk recording.

Conclusion

The research results indicate significant difference in animals' response to heat stress effect due to a breeding region and individual's susceptibility to heat stress. The most pronounced and persistent negative effect of heat stress was determined in cows bred in the Eastern region of the country. Also, the negative effect of heat stress was more pronounced and more persistent in Simmentals that were heat stressed at lower THI threshold values (cows that are more susceptible to heat stress).

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Утицај регије узгоја на разлике у перзистенцији утицаја температурног стреса у првотелкама сименталске пасмине

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Сажетак

У циљу утврђивања утицаја регије узгоја на перзистенцију ефекта температурног стреса код првотелки сименталске пасмине анализирани су записи на контролни дан преузети од Хрватске пољопривредне агенције. Краве код којих је утврђен статистички значајан пад дневне количине млијека при дефинисаним вриједностима температурно-хумидног индекса THI (65, 70 i 75) укључене су у даља испитивања. Перзистенција утицаја температурног стреса, с обзиром на дневне карактеристике анализиране млијечности, дефинисана је као апсолутни пад у сукцесивним контролама млијечности (1. и 2.). Резултати овога истраживања указују на значајну разлику у реакцији крава на температурни стрес у зависности од регије узгоја те осјетљивости грла на температурни стрес. Најизраженији те дуготрајнији негативни утицај температурног стреса утврђен је код крава узгајаних у источној Хрватској. Надаље, негативни утицај температурног стреса био је израженији и дуготрајнији код крава осјетљивијих на температурни стрес (код температурног стреса при нижим вриједностима THI).

Кључне ријечи: температурни стрес, перзистенција, првотелке сименталске пасмине, дневна својства млијечности, регија узгоја

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