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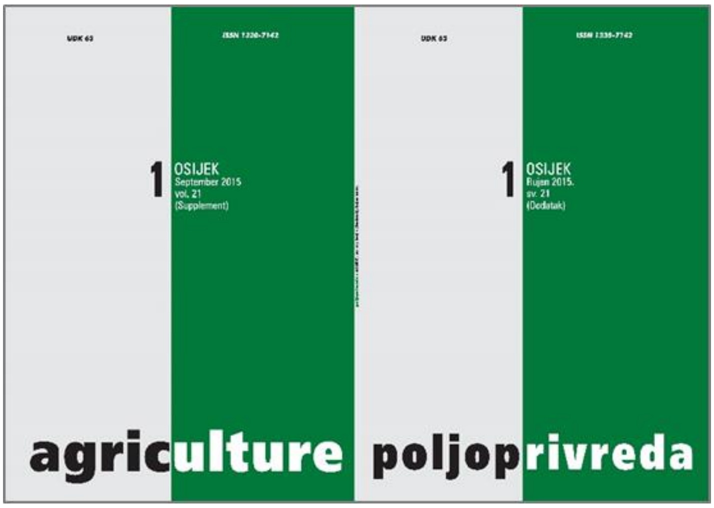

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HEAT STRESS AND MILK PRODUCTION IN THE FIRST PARITY HOLSTEINS – THRESHOLD DETERMINATION IN EASTERN CROATIA

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SUMMARY

In the light of increasingly rapid climate change worldwide, one of the primary goals is to reduce financial losses of dairy farmers and to enable the sustainable farming. In order to realize those goals, the necessity of implementation of breeding values for heat resistance in breeding strategies, have become more and more pronounced. Estimation of breeding values requires determination of temperature-humidity index (THI) threshold value. Therefore, the objective of this research was to determine the THI threshold value for the first parity Holsteins in environmental conditions in Eastern Croatia. With that purpose individual test-day records of the first parity Holsteins with records of ambient temperature and relative humidity in the barns were analysed. Data were collected in regular milk recording from January 2006 to December 2012. The THI threshold values for daily milk yield were determined by least square analyses of variance for each given THI value (from 65 to 76) using the PROC MIXED (SAS). The THI <68 did not cause significant change in daily milk production of the first parity Holsteins. Significant decrease of daily milk yield was observed at THI ≥ 68 with estimated drop from 0.240 to 0.716 kg milk/day (THI from 68 to 76). The THI=68, as the lowest value at which significant decrease in daily milk yield was determined, was taken as the threshold value for the first parity Holsteins in Eastern Croatia.

Key-words: first parity Holsteins, heat stress, temperature-humidity index, threshold, Eastern Croatia

INTRODUCTION

In the last few decades, we have witnessed more expressed and increasingly rapid climate change worldwide meaning, that in regions that currently are not characterized as extreme climate conditions, in future dairy cattle will be exposed to the unfavourable climatic conditions (IPCC, 2007). In accordance with this forecast, Reiczigel et al. (2009), in Hungary, determined increase of heat stress days/year (temperature-humidity index – THI>68) from 5 to 17 in the period of 30 years. Considering dairy cattle breeding in indoor housing, optimal microclimate conditions in the barns are necessary in order to realize the productive potential of individual cows. The interrelation between ambient temperature and relative humidity is relevant for animal welfare, reproduction traits and dairy farm profitability. Any extreme combinations are potentially harmful. On one hand, environmental conditions with low temperature and high humidity induce the cows to increase heat production and feed consumption in order to compensate body energy losses. Moreover, when the animal is overheated, high humidity may lead to infections of respiratory tract or udder. On the other hand, high temperature and low relative humidity may dehydrate mucous membranes thus increasing vulnerability to viruses and bacteria (Romaniuk and Overby, 2005). The combination of high temperature and high relative humidity has the most detrimental effect through inducing heat stress in cows. Under heat stress conditions,

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lactating cows tend to reduce level of dry matter intake (DMI) and milk production (West et al., 1999). Moreover, beside milk production reduction, heat stress is associated with changes in milk composition, somatic cell counts (SCC) and mastitis frequencies (Bouraoui et al., 2002.; Collier et al., 2012; Correa-Calderon et al., 2004; Ravagnolo et al, 2000.; St-Pierre et al., 2003; West, 2003). Additionally, deteriorate effect on reproductive performances was also observed (Bohmanova et al., 2007; Ravagnolo et al., 2000). Numerous studies showed that the high producing cows are much more susceptible to heat stress than low producing ones (Bohmanova, 2006; Collier et al. 2006). Kadzere et al. (2002) suggested that, due to intensive genetic selection for milk production, the thermoregulation physiology of a cow has been changed. The high producing cows have larger frames and larger gastrointestinal tracts allowing digestion of more feed and results in more metabolic heat, which consequently reduces cow's ability to maintain normal temperature at unfavourable temperature conditions. Finally, high producing cows experience heat stress earlier than low producing cows since the thermoneutral zone of high producing cows is at lower temperatures. The most common measure of heat stress in dairy cows is the temperature-humidity index (THI) that present combination of ambient temperature and relative humidity and is a useful and easy way to assess the risk of heat stress (Kibler, 1964). Du Preez et al. (1990a,b) determined that milk production and feed intake is affected by heat stress if THI values are higher than 72. Bouraoui et al. (2002) put the THI threshold on 69, while Bernabucci et al. (2010) as well as Collier et al. (2012) on 68. Vitali et al. (2009) suggested that the risk of cow's death started to increase when THI reached 80. The significant decrease of daily milk traits (yield and contents) was also determined in Croatian environmental conditions with the highest decline during summer period in Eastern and Mediterranean Croatia (Gantner et al., 2011). In many dairy-producing areas of the world heat stress condition represents a significant financial burden, for example in the USA between $897 and $1,500 million per year (St-Pierre et al., 2003). There are many methods to decrease the impact of heat stress including the shading, cooling, nutrition (Kadzere et al., 2002; West, 2003) and selection for resistance on heat stress (Bohmanova, 2006). Ravagnolo et al. (2000) determined antagonistic relationship between cow's production and heat tolerance implying deteriorate effect of selection on productivity and cow's resistance to heat stress. The high yielding Holstein cows in Israel is good example how selection on production could be successful in terms of heat stress (Aharoni et al., 1999). Implementation of breeding values for heat resistance in breeding strategies would certainly reduce financial losses of dairy farmers and enable sustainable farming. Estimation of breeding values requires determination of THI threshold value. Therefore, the objective of this research was to determine the THI threshold value for first parity Holsteins in environmental conditions in Eastern Croatia.

MATERIAL AND METHODS

For statistical analysis the individual test-day records of the first parity Holsteins collected in regular milk recording performed by alternative milk recording method from January 2006 to December 2012 were used. Monthly, at each recording, milk yields were measured during the evening or morning milkings. Additionally, ambient temperature and relative humidity in the barns were recorded at each recording. Logical control of milk data was performed according to ICAR standards (2003). Daily temperature-humidity index (THI) was calculated using the equation by Kibler (1964):

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

where Ta is average temperature in Celsius degrees 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 or parity >1, and missing or nonsense Ta and RH value were deleted from dataset. Data, provided by the Croatian Agricultural Agency, after logical control, consisted of 171,665 test-day records from 23,604 first parity cows reared on 1,805 farms in Croatia. Variability of ambient temperature (Ta) and relative humidity (RH) per recording year in Eastern Croatia is presented in Table 1.

Table 1. Descriptive statistics of ambient temperature (Ta) and relative humidity (RH) measured during the milk recording regarding the recording year in Eastern Croatia

Recording year	Ambient temperature (ºC)					Relative humidity (%)				
	Mean	SD	CV	Min	Max	Mean	SD	CV	Min	Max
2006	13.9	7.68	55.3	-9.0	37.0	69.5	10.08	14.5	35.0	99.0
2007	14.5	7.63	52.4	-3.0	39.0	69.6	10.58	15.2	30.0	98.0
2008	14.5	7.56	52.1	-6.0	38.0	69.0	10.82	15.7	30.0	97.0
2009	13.7	8.08	59.2	-9.0	40.0	68.6	11.72	17.1	32.0	98.0
2010	12.7	7.95	62.8	-9.0	36.0	70.9	12.45	17.6	35.0	99.0
2011	12.9	8.38	64.9	-9.0	39.0	70.7	11.93	16.9	30.0	98.0
2012	13.8	8.90	64.6	-9.0	40.0	69.2	12.59	18.2	30.0	99.0

The THI threshold values for daily milk yield were determined by least square analyses of variance for each given THI value (from 65 to 76) using the PROC MIXED procedure in SAS (SAS Institute Inc., 2000). The following mixed model was used:

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

where y_{ijklm}=estimated daily milk yield; μ=intercept; b_1, b_2, b_3, b =regression coefficients; d_i=days in milk (i= 6 to 305 day, 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 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*)), and e_{ijklm}=residual.

The significance of the differences between the THI classes was tested by Scheffe's method of the multiple comparisons. The lowest threshold value at which significant differences in milk yield was determined has been taken as the THI threshold value.

RESULTS AND DISCUSSION

Least square means from analysis of variances regarding the fixed effect of THI class (0, 1) on daily milk yield are shown in Table 2. Environmental conditions in the barns that characterise THI values in 65, 66 and 67 did not cause significant difference in daily production of the first parity Holsteins. High statistically significant ($p<0.001$) decrease of daily milk yield was observed at THI value above 67, from 68 to 76. When THI value exceeded 67, the estimated drop in milk yield was from 0.240 to 0.716 kg/day. The highest decrease was determined in environmental condition characterised by THI=74. The lowest value, at which significant differences in milk yield was determined has been taken as the threshold value. Therefore, in the environmental conditions of Eastern Croatia, THI threshold value for the first parity Holsteins 68 was set to 68. Significant drop in daily production for dairy cattle at the same THI value was also determined by Bernabucci et al. (2010) and Collier et al. (2012). Bouraoui et al. (2002), in a Mediterranean climate, observed milk production decrease in condition characterised by THI ≥ 69.

Table 2. Least square means of cow's milk yield (kg/day) regarding the given THI threshold value

ThHo	Ls0	Ls1	Estimated difference
THI65	20.09 ± 0.100	20.10 ± 0.105	-0.005 ± 0.044n.s.
THI66	20.09 ± 0.093	20.11 ± 0.099	-0.028 ± 0.047n.s.
THI67	20.10 ± 0.093	20.06 ± 0.100	0.043 ± 0.049n.s.
THI68	**20.14 ± 0.093**	**19.90 ± 0.101**	**0.240 ± 0.050*****
THI69	20.17 ± 0.094	19.71 ± 0.102	0.461 ± 0.051***
THI70	20.18 ± 0.093	19.60 ± 0.102	0.588 ± 0.052***
THI71	20.17 ± 0.093	19.59 ± 0.104	0.583 ± 0.054***
THI72	20.17 ± 0.091	19.47 ± 0.104	0.701 ± 0.057***
THI73	20.16 ± 0.093	19.45 ± 0.107	0.715 ± 0.059***
THI74	20.15 ± 0.092	19.44 ± 0.108	0.716 ± 0.063***
THI75	20.12 ± 0.093	19.74 ± 0.110	0.377 ± 0.064***
THI76	20.12 ± 0.093	19.71 ± 0.112	0.407 ± 0.067***

ThHo–given threshold value; 0–class under, and 1–class above the given threshold value;***-p<0.001; n.s.-non significant

Du Preez et al. (1990a,b) determined that dairy cows in Southern African conditions were affected by heat stress when THI values were higher than 72. The significant decrease of daily milk yield, when THI≥72, was also determined in Eastern and Mediterranean Croatia (Gantner et al., 2011). Bohmanova et al. (2007), in USA, determined different threshold values regarding different regions (72 in Georgia, and 74 in Arizona). The difference between determined threshold values could be due to better adapted cows, farm management or special housing characteristics.

CONCLUSION

Based on analysed data it could be concluded that temperature-humidity index (THI) <68 did not cause significant change in the first parity Holstein's daily production. Significant decrease of daily milk yield was observed at THI ≥68 with estimated drop from 0.240 till 0.716 kg milk/day (THI from 68 to 76). The THI=68, as the lowest value at which significant decrease in daily milk yield was determined, has been taken as the THI threshold value for the first parity Holsteins in Eastern Croatia.

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