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Effect of temperature-humidity index on daily milk yield of dairy cows

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ABSTRACT

The objective of this study was to evaluate the effects of temperature-humidity index on daily milk yield of dairy cows under climate conditions in Croatia. In this study 103.569 individual test-day milk yield records of first lactation cows from Central data base of Croatian Livestock Centre were analysed. Data were collected in regular milk recording by alternative milk recording scheme from January 2005 to December 2005. According to lactation stage, cows were divided into five groups, L1 (<60 days), L2 (60–120 days), L3 (120–150 days), L4 (150–180 days), L5 (>180 days). Average temperature-humidity index, during spring, autumn and winter period was under chritical THI, so, lack of heat stress conditions characterized these periods. During the summer period, average ambient temperature and relative humidity were 22.71±4.76 °C and 70.30±9.78%, while the average THI was 70.30±7.12. Only, during July, chritical THI was exceeded. In the first 120 days of lactation, daily milk yield was higher in spring period than in the other periods, while if lactation was longer than 120 days, the highest daily milk yield production was in summer period. The highest daily fat and protein content was obtained in winter period, for all lactation stages. The linear regression of daily milk yield, fat and protein content to temperature-humidity index indicates that daily milk yield, fat and protein content slightly decreases as THI increases. Further investigations, in which effect of feeding could be eliminated, is needed.
(Keywords: temperature-humidity index, daily milk yield, dairy cows)

INTRODUCTION

Heat stress is cause of high economic losses in the dairy industry. When dairy cattle are exposed to high ambient temperatures (Ta), high relative humidity (RH) and solar radiation for extended periods, the ability of the lactating dairy cow to disperse heat decreases. Also, lactating dairy cows create a large quantity of metabolic heat. So, accumulated and producted heat joined with decreased cooling capability induced by environmental conditions, causes heat strees in the animals. Finally, heat stress induces increase of body temperature as well as decrease of feed intake and productivity. The Temperature-Humidity Index (THI) could be used to determine the influence of heat stress on productivity of dairy cows. Milk production is affected by heat stress when mean THI values are lower then 35 and higher then 72 (*Du Preez et al*., 1990). *Johnson* (1980) reported that, when THI reaches 72, milk production as well as feed intake begin to decrease. The amount of milk yield decreases during the summer period in comparision to the winter period for Holstein cows about 10% to 40% (*Du Preez et al.*, 1990). Under Mediterranean climatic conditions, milk yield drops by 0.41 kg per cow per day for each point increase in the value of THI above 69 (*Bouraoui et al.*, 2002). Beside changes in milk yield, heat stress could also cause changes in milk composition, milk somatic cell counts (SCC) and mastitis frequencies (*Rodriguez et al.*, 1985; *Du Preez et al.*, 1990). The objective of this study was to evaluate the effects of temperature-humidity index on daily milk yield of dairy cows under climate conditions in Croatia.

MATERIALS AND METHODS

In this study 103.569 individual test-day milk yield records of first lactation cows from Central data base of Croatian Livestock Centre were used. Data were collected in regular milk recording by alternative milk recording scheme from January 2005 to December 2005. At each recording, milk yields was measured in the evening or in the morning. Also, at each milking, initial time of current milking and initial time of previous milking for each animal was registrated. The interval between successive milkings was computed as the time from the beginning of previous milking to the beginning of current milking. For analysis of milk composition one sample at each milkings was taken from each cow. Daily milk yield and fat content was projected from partial values (evening or morning) according to correction factors by *DeLorenzo* and *Wiggans* (1986). Logical control of data was performed according to *ICAR* standards (2003). Variability of daily milk yield, fat and protein content is reported in *Table 1*.

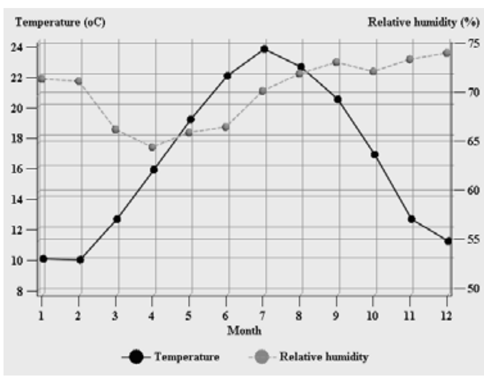
Table 1

Descriptive statistics for milk traits (n=103.569)

Trait	Mean	SD	CV	Min	Max
Daily milk yield, kg	15.87	6.33	39.90	3.00	82.32
Daily fat content, %	4.22	0.86	20.35	1.51	8.98
Daily protein content, %	3.41	0.44	13.04	1.40	6.91

Figure 1

Average measured temperature and relative humidity per months



According to lactation stage, cows were divided into five groups, L1 (<60 days), L2 (60–120 days), L3 (120–150 days), L4 (150–180 days), L5 (>180 days). Additionally, at each milking, temperature and relative humidity in stall were recorded. Daily temperature-humidity index (THI) values were calculated using the equation by *Kibler* (1964).

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

Ta: measured ambient temperature in °C, RH–relative humidity as a fraction of the unit.

Distribution of average daily temperature and relative humidity according to months are shown on *Figure 1*. For estimation of the effect of season and temperature – humidity index on daily milk yield, as well as, on daily fat and protein content following fixed – effect model was used:

$$y_{ijk} = \mu + S_{ij} + b_i t_{ijk} + e_{ijk}$$

where: y_{ijk} = observation on kth test-day on the jth season in the ith class of lactation stage,
μ= intercept,
S_{ij} = effect of season *j* nested within classes of lactation stage *i,*
b_i = regression coefficient on the temperature – humidity index nested within classes of lactation stage *i,*
t_{ijk} = temperature – humidity index on kth test-day on the jth season in the ith class of lactation stage,
e_{ijk} = residual.

The significance of differences between the means of daily milk yield, fat and protein content within the season in relation to classes of lactation stages was tested with Scheffe test. For statistical analysis the SAS/STAT package was used (*SAS Institute Inc*., 2000).

RESULTS AND DISCUSSION

Variability of ambient temperature (Ta), relative humidity (RH) and temperatury-humidity index (THI) per season is shown in *Table 2*. *Berman* (1985) reported that the upper critical temperature for Holsteins is 25 to 26 ^{o}C, while, when THI surpass the level of 72, cows decrease milk production (*Johnson*, 1980). In the spring period, average ambient temperatute and relative humidity were 15.84±5.80 ^{o}C and 65.64±10.37%, respectively. Average THI was 59.89±8.40 and did not exceeded chritical THI (*Figure 2*). That means that envitomental conditions, in spring period, were not heat stressfull.

Table 2

Enviromental conditions during the seasons (n=103.569)

Season*	Temperature, Ta (^{o}C)			Relative humidity, RH (%)			THI		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Spring, S1	15.84	5.80	36.66	65.64	10.37	15.81	59.89	8.40	14.03
Summer, S2	22.71	4.76	20.94	69.46	9.78	14.09	70.30	7.12	10.13
Autumn, S3	16.56	5.70	34.39	73.11	9.10	12.45	61.21	8.71	14.22
Winter, S4	10.19	3.89	38.15	72.54	9.24	12.74	51.48	5.93	11.52

*Spring, S1 (March, April and May), Summer, S2 (June, July and August), Autumn, S3 (September, October and November), Winter, S4 (December, January and February).

Figure 2

Average THI variation during the summer period

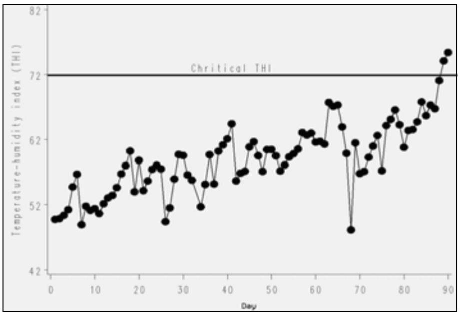
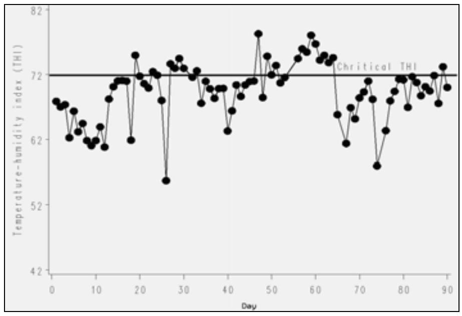


Figure 3

Average THI variation during the spring period



Average temperature-humidity index, during autumn and winter period was under chritical THI (*Figure 4* and *5*), so, lack of heat stress conditions also characterized autumn and winter period. During the summer period, average ambient temperature and relative humidity were 22.71±4.76 ^{o}C and 70.30±9.78%, while the average THI was 70.30±7.12 (*Table 2*). During July, chritical THI was exceeded (*Figure 3*).

Figure 4

Average THI variation during the winter period

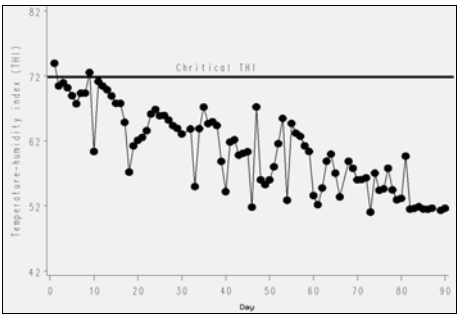
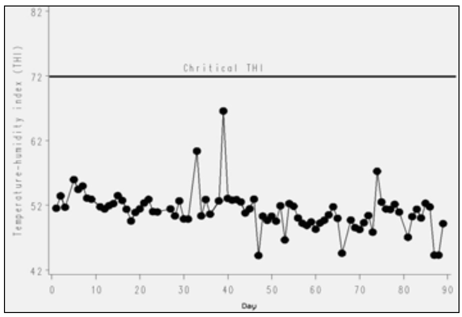


Figure 5

Average THI variation during the autumn period



Least square means of daily milk yield, fat and protein content for seasons in relation to classes of lactation stage are shown in *Table 3*. In the first 120 days of lactation (classes L1 and L2), daily milk yield production was higher in spring period than in other periods, while if lactation was longer than 120 days, the highest daily milk yield production was in summer period. The differences between seasons were statistically significant for all lactation stages.

Obtained results are not in agreement with those reported in literature (*Du Preez et al.*, 1990) which could be induced by different environmental conditions in our study. Increase of the amount of milk yield during the summer period in comparision to the winter period could also be explained by inadequate and insufficient feeding during winter period. If daily fat content is taken into consideration, the differences between seasons were statistically significant and the highest content was during the winter period, for all lactation stages. Increase of daily fat content during winter period could be attributed to the increase in forage intake, while the decrease of daily fat content during the summer period in comparision to the spring period could be caused by heat stress enviroments in the summer period. The highest protein content was obtained in winter period, also, for all lactation stages. Descease of daily fat and protein content during summer period in regard to spring period was also reported by *Bouraoui et al*. (2002).

Table 3

Least square means of daily milk yield, fat and protein content for seasons in relation to classes of lactation stage

Classes of lactation stage	Season	Daily milk yield, kg	Daily fat content, %	Daily protein content, %
L1	S1	19.99^{A}	4.02^{A}	$3.09^{A, C, a}$
	S2	$18.96^{B, C, b}$	3.90^{B}	3.03^{B}
	S3	18.11^{D}	4.06^{A}	$3.12^{A, C, c}$
	S4	$18.41^{B, C, c}$	4.23^{C}	3.17^{D}
L2	S1	19.03^{A}	3.91^{A}	3.18^{A}
	S2	18.77^{A}	3.78^{B}	3.09^{B}
	S3	16.62^{B}	3.95^{A}	3.21^{C}
	S4	16.50^{B}	4.13^{C}	3.22^{C}
L3	S1	17.46^{A}	$4.01^{A, C, a}$	3.34^{A}
	S2	17.81^{A}	3.90^{B}	3.24^{B}
	S3	15.45^{B}	$4.08^{A, C, c}$	$3.37^{A, C}$
	S4	14.70^{C}	4.22^{D}	3.40^{C}
L4	S1	16.20^{A}	$4.10^{A, C, a}$	3.41^{A}
	S2	17.10^{B}	3.98^{B}	3.32^{B}
	S3	14.91^{C}	$4.16^{A, C, c}$	3.45^{C}
	S4	13.31^{D}	4.34^{D}	3.48^{C}
L5	S1	13.11^{A}	4.41^{A}	3.63^{A}
	S2	14.59^{B}	4.23^{B}	3.51^{B}
	S3	13.59^{C}	4.45^{C}	3.68^{C}
	S4	12.22^{D}	4.59^{D}	3.71^{D}

*The values, within classes of lactation stages, marked with the same letter are not (highly) significantly different (P>(0.01) 0.05).

Figure 6 shows relation of daily milk yield to temperature-humidity index according to classes of lactation stage. The negative slope of the regression line, for all lactation stages with exception of stage L4, indicates that milk production decreases as THI increases. The most intensive decrease is in second lactation stage or between 60^{th} and 120^{th} day of lactation (*Table 4*). Higher decrease of daily milk yield in relation to temperature-humidity index in mid-lactating Friesian–Holstein cows (144 to 150 days postpartum) was reported by *Bouraoui et al*. (2002).

Decrease of daily fat and protein content in regard to temperature-humidity index according to classes of lactation stage is shown on *Figure 7* and *8*.

Figure 6

Relation of daily milk yield to temperature-humidity index

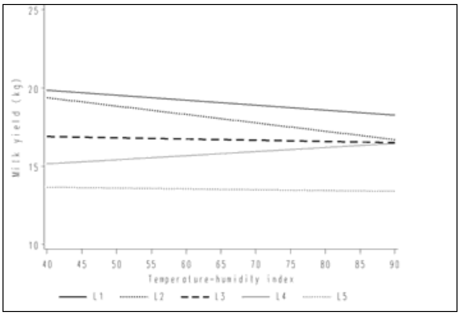


Figure 7

Relation of daily fat content to temperature-humidity index

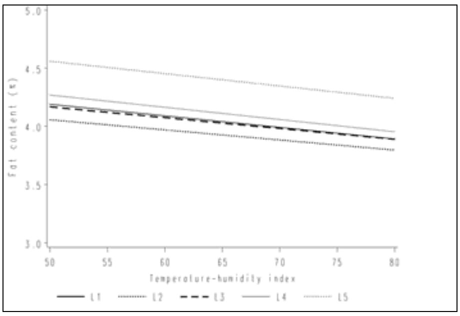
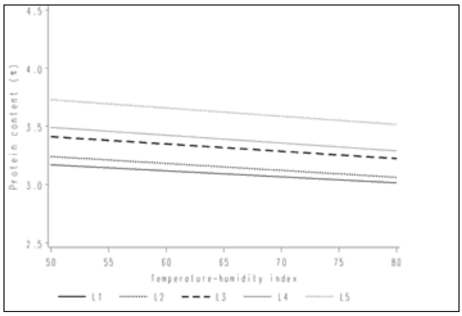


Figure 8

Relation of daily protein content to temperature-humidity index



The negative regression coefficient (*Table 4*), for all lactation stages, indicates that daily fat and protein content slightly decreases as THI increases.

Table 4

Regression coefficient on the temperature – humidity index in relation to classes of lactation stage

Trait	Classes of lactation stage				
	L1	L2	L3	L4	L5
Daily milk yield, kg	-0.0317	-0.0535	-0.0077	+0.0259	-0.0053
Daily fat content, %	-0.0100	-0.0088	-0.0093	-0.0106	-0.0106
Daily protein content, %	-0.0052	-0.0059	-0.0063	-0.0067	-0.0071

CONCLUSIONS

Based on present research it could be concluded that in the first 120 days of lactation, daily milk yield was higher in spring period than in the other periods, while if lactation was longer than 120 days, the highest daily milk yield production was in summer period. The highest daily fat and protein content was obtained in winter period, for all lactation stages. The linear regression of daily milk yield, fat and protein content to temperature-humidity index indicates that daily milk yield, fat and protein content slightly decreases as THI increases. Further investigations, in which effect of feeding could be eliminated, is needed.

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