Original Article

Relationship of temperature-humidity index with milk production and feed intake of holstein-frisian cows in different year seasons

Tibor Könyves[1] Nebojša Zlatković[2] Nurgin Memiši[3] Dragomir Lukač[1*] Nikola Puvača[4] Milan Stojšin[1] Andras Halász[5] Branislav Miščević[1]

Abstract

The objective of this study was to assess the relationship of temperature-humidity index (THI) with milk production, feed intake and feed efficiency of Holstein-Frisian cows in different seasons of the year. Five hundred and sixty three cows were monitored in spring, 557 cows in summer, 594 cows in autumn and 567 cows in winter, for a total period of two years. In contrast to the spring, autumn and winter periods, the summer period was characterized by heat stress conditions. Average T and THI exceeded the 25°C and 72 critical points, respectively, on all, 90% and 93% of test days for this period, indicating that the cows were exposed to heat stress during the summer trial. The heat stress reduced daily milk yield by 1.32 kg or 9.46%, by 0.92 kg or 9.62% and by 1.27 kg or 9.48% as the THI values went from 64 in the spring, from 66 in the autumn and from 42.34 in the winter periods to 79 in the summer period. Forage intake was decreased by 1.63 kg, by 1.42 kg and by 1.25 kg compared to those in spring, autumn and winter, respectively, and the efficiency of conversion of feed to milk was increased (from 1.6 to 1.59 kg milk/kg milk). The regression equation obtained under the conditions of the present work indicates that daily milk yield drops, daily forage intake drops per cow per day and food efficiency increases per kg food when the value of THI increases. In conclusion, summer heat stress negatively affects milk yield and forage intake of dairy cows. Therefore, management strategies are needed to minimize the heat stress and attain optimal dairy cow productivity.

Keywords: temperature, relative humidity, milk production, feed intake

[1]*John Naisbitt University Belgrade, Faculty of Biofarming, Maršala Tita 39. Bačka Topola, Serbia*
[2]*Faculty for Agriculture and Food Technology, Ćirila i Metodija 1. Prokuplje, Serbia*
[3]*Dairy Plant Subotica, Tolminska 10. Subotica, Serbia*
[4]*University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8. Novi Sad, Serbia*
Patent Co., Vlade Ćetkovića 1a. Mišićevo, Serbia
[5]*Szent István University, Faculty of Agricultural and Environmental Sciences, Pater Karoly 1. Godollo Hungary*
***Correspondence**: dragomirlukac@gmail.com*

Introduction

Throughout several decades, the selection of high-yielding dairy breeds of cattle has directed towards improving genetic predisposition for higher production of milk and quantity of consumed feed. According to Scholtz et al. (2013), despite the success achieved, the main environmental factors affecting dairy cow production are ambient temperature, humidity, solar radiation and wind (Hulme, 2005). Most studies of the heat stress in livestock have concentrated mainly on temperature and relative humidity (Correa-Calderon et al., 2004; Bouraoui et al., 2002) because data of the amount of thermal radiation received by animal, wind speed, and rainfall are not generally available. High temperature decreases feed intake in order for animals to reduce digestive heat production, whereas sweating and water intake increase. It is known that during heat stress, reduction in feed intake and milk yield and negative energy balance occur (West, 2003; Mader et al., 2006). Some factors such as breed, age, sex, condition and physiological shape have influence on the nature of animal's biological response to the stressor (Nardone et al., 2006). Other factors involved in thermal comfort include the external coat of animal (thickness, structure, thermo isolation, absorption and reflectivity) and body traits (shape, size and superficial area) (Silva, 2000).

Previous studies have shown that cows are more sensitive to heat stress when they are in the middle or at the end of lactation (Spiers et al., 2004). This phenomenon can be explained by the fact that at the beginning of lactation the productivity depends on the possibility of cows to use their own sources of energy, while the later productivity depends on the energy used from food (Bernabucci et al., 2010). The temperature scope from -0.5 to +20°C has little effect on milk production. The upper critical air temperature for lactating cows is in the range of 25-26°C (Broucek, 2009; West, 2003). However, according to Aharoni et al. (2002) and Mader et al. (2006), critical temperatures will vary depending on several factors including degree of acclimatization, rate of production, pregnancy status, air movement around the animals and relative humidity. Heat stress in dairy cattle can be managed by using different approaches such as cooling, shading and nutrition (Arjomandfar et al., 2010; Ghavi Hossein-Zadeh et al., 2013).

A temperature-humidity index (THI) is a single value depicting the integrated effects of air temperature and humidity associated with the level of heat stress. This index has been developed as a weather safety index to control and decrease the heat stress-related losses (Bohmanova et al., 2007). THI is widely used in hot areas all over the world and is commonly used as a practical indicator for the degree of stress on dairy cattle caused by weather conditions (Hahn and Mader, 1997; Bray et al., 1997; Brown-Brandl et al., 2003) because THI incorporates the effects of both ambient temperature and relative humidity in an index. Heat stress in dairy cows occurs when the THI index is higher than 72 (Ravagnolo and Misztal, 2000; Dikmen and Hansen, 2009) and milk yield and feed intake start to decline (Bouraoui et al., 2002; Herbut and Angrecka, 2012). According to Du Preez et al. (1990), milk production is not affected by heat stress when mean THI values are between 35 and 72. However, in the warning to critical range of THI of 70-72, performance of dairy cattle is inhibited and cooling becomes desirable (Broucek, 2009). At THI of 72-78, milk production is seriously affected. In the dangerous category at THI of 78-82, performance is severely affected and cooling of the animals becomes essential (Brown-Brandl et al., 2003; Broucek, 2009). Milk yield reductions of 10 to 40% have been reported for Holstein cows during summer as compared to winter (Du Preez, 1990). In Germany, Brügemann et al. (2012) indicated a milk yield decline between 0.08 and 0.26 kg for every increase in THI unit, depending on the region. When the THI value increased from 68 to 78, milk production was reduced by 21% and dry matter intake was reduced by 9.6% (Bouraoui et al., 2002). Moreover, heat stress is associated with alterations in milk composition, milk somatic cell counts and mastitis incidences (Du Preez, 1990).

Therefore, the objective of this study was to assess the relationship of temperature-humidity index (THI) with milk production, forage intake and food efficiency of Holstein-Frisian cows in Vojvodina (Serbia) in different seasons of the year.

Materials and Methods

Data set and animal management: The study was conducted at a large commercial dairy herd in Serbia, Vojvodina, which has a temperate continental climate. Five hundred and sixty three cows were monitored in spring, 557 cows in summer, 594 cows in autumn and 567 cows in winter, for a total period of two years. The cows were grown under the same conditions of nutrition and care while experiments were conducted with similar protocols. All cows had balanced parity and stage of lactation. Cows in the spring experiment calved from mid-January to mid-February and had an average lactation number of 3.24 ± 0.62. Cows in the summer experiment calved from mid-April to mid-May and had an average lactation number of 2.92 ± 0.78. Cows in the autumn experiment calved from mid-July to mid-August and had an average lactation number of 3.09 ± 0.38 and cows in the winter experiment calved from mid-October to mid-November and had an average lactation number of 2.75 ± 0.74. The animals were in free housing. The floor of the barn was filled with straw and the mat was regularly changed twice a day. Diets were typical of those in the region and consisted of 52% corn silage, 13% alfalfa hay and 35% concentrate mix of corn, soybean meal and sunflower meal. The concentrate mix was also supplemented with mineral and vitamin. The corn silage and alfalfa hay were fed *ad libitum*. The concentrate was fed in two equal meals daily. The forage and concentrate were separately provided to the cows to allow measurement of individual refusals. To determine daily forage intake, amounts of the feed offered and refused were recorded daily throughout the experiments. Refused feed was removed and weighed daily. Drinking water was made available at all times. Milk yields, forage intake and feed efficiency were monitored daily throughout the period of two years. The cows were milked twice a day (7:00 and 13:00 h) and milk yield of each cow was recorded individually at each milking on all test days. Feed efficiency (yield kg milk per kg feed) was calculated for each period.

Meteorological data: Ambient temperature and relative humidity within the barns were recorded at one hour intervals by data loggers (HygroLogger). In farm, 6 data loggers were installed, with 3 placed in the lying and 3 in the feeding area at a height of 3 m above the ground. Temperature-humidity index (THI) was calculated on the basis of meteorological data and measurements on the farm according to the formula of the National Research Council [NRC 1971]:

$$THI = (1.8 \times T + 32) - (0.55 - 0.0055 \times RH) \times (1.8 \times T - 26)$$

where T = air temperature in degrees Celsius and RH = relative humidity in percent.

Months were grouped into four seasons: Spring (March, April, May), Summer (June, July, August), Autumn (September, October, November) and Winter (December, January, February). Summary of statistics of environmental conditions during the experimental periods is shown in Table 1.

Statistical analysis: Data were analyzed using ANOVA and regression procedures in the Statistical package SAS. To determine the effect of seasons and THI as linear regression on milk yields, roughage intake and food efficiency, a mixed model was used, in which repeated measurements per cow were considered randomly and auto-correlated. On the basis of defining different sources of variability on daily milk yield, roughage intake and food efficiency, the statistical model was:

$$Y_{ijk} = \mu + S_i + K_j(S_i) + W_k(K_j) + e_{ijk}$$

where Y_{ijkl} = mean phenotypic value of observed trait, μ = average mean value of observed traits, S_i = effect of season i, $K_j(S_i)$ = effect of cow j nested within season i, $W_k(K_j)$ = effect of week k nested within cow j, and e = random error.

Seasonal differences in daily milk yield, roughage intake and food efficiency were tested using the Fisher LSD post-hoc test, and a regression equation was developed between analyzed traits and THI.

Results

Mean, standard deviation, maximum and minimum temperature (T), relative humidity (RH) and calculated temperature-humidity index (THI) during the experimental periods are shown in Table 1. Spring, autumn and winter were characterized by the lack of heat stress condition which was characterized by the upper critical temperature and THI for Holsteins of 25-26°C and 72, respectively. The minimum and maximum T and RH in spring were -2.00 and 33.00°C and 29.00 and 96.00%, in autumn 1.00 and 33.00°C and 41.00 and 97.00%, and in winter -12.00 and 15.00°C and 48.00 and 96.00%, respectively. The average T and THI in spring was 19.17 ± 7.11°C and 64.21 ± 9.88, in autumn 20.45 ± 7.12°C and 66.36 ± 10.39 and in winter 4.6 ± 5.41°C and 42.34 ± 8.66, respectively. The average T and average THI were higher than the critical values of 25°C and 72 on only 18 and 20% of all test days for spring and 34 and 40% of all test days for autumn. In the winter period there were no higher critical values. In contrast to the spring, autumn and winter periods, the summer period was characterized by the heat stress conditions. To wit, the average T and THI in summer were 30.52 ± 4.53°C and 79.31 ± 5.25, and the minimum and maximum T and RH in summer were 20.00 and 40.00°C and 30.00 and 85.00%, respectively. The average T and THI exceeded the 25°C and 72 critical points, respectively, on all, 90% and 93% of the test days for this period, indicating that the cows were exposed to heat stress during the summer trial.

Table 1 Environmental conditions during the seasons

Parameters	Seasons			
	Spring	Summer	Autumn	Winter
Average daily T, (°C)	19.17	30.52	20.45	4.6
Standard deviation, (°C)	7.11	4.53	7.12	5.41
T, minimum (°C)	-2.00	20.00	1.00	-12.00
T, maximum (°C)	33.00	40.00	33.00	15.00
Average daily RH, (%)	61.59	53.97	68.74	77.57
Standard deviation, (%)	15.74	12.07	13.47	10.49
RH, minimum (%)	29.00	30.00	41.00	48.00
RH, maximum (%)	96.00	85.00	97.00	96.00
Average daily THI	64.21	79.31	66.36	42.34
Standard deviation	9.88	5.25	10.39	8.66
THI, minimum	29.53	65.52	34.46	17.38
THI, maximum	81.75	91.30	83.31	58.79

T = temperature, RH = relative humidity, THI = temperature-humidity index

Weekly average temperature, humidity and THI variations during each season are given in Figure 1. The temperature and THI averages exceeded the threshold of heat stress of > 25°C and > 72, respectively, in the summer and half of the autumn periods, or in the months from June to September. From June to September this threshold was exceeded almost every day.

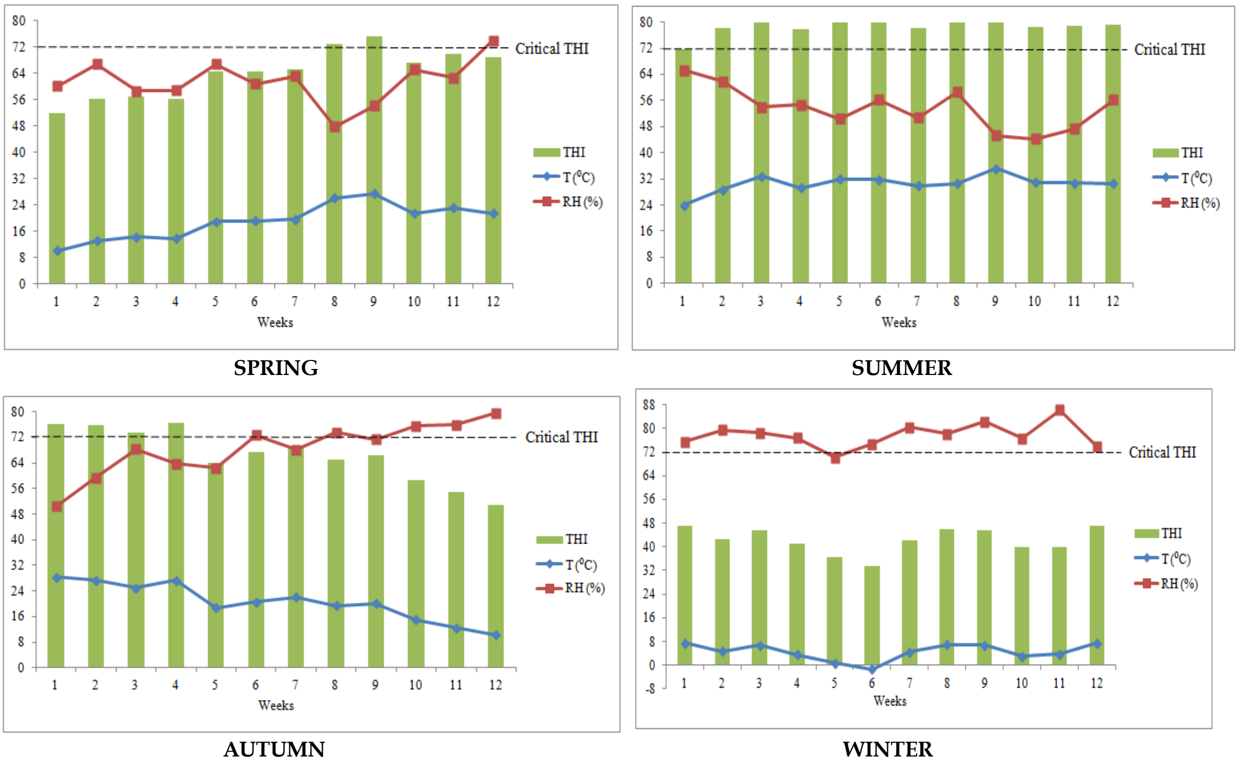

Figure 1 Average weekly temperature (T), relative humidity (RH) and temperature-humidity index (THI) during the seasons in a year

Average means and their standard deviations for the effect of THI on productive traits are shown in Table 2. The results in Table 2 showed a significant ($P < 0.05$) heat stress effect on daily milk yield, forage intake and food efficiency. According to the results of the present study, the cows in spring had significantly higher ($P < 0.05$) daily milk yields (24.64 ± 0.74) than the cows in summer and autumn seasons; the cows in summer had the lowest (23.32 ± 1.22). The heat stress reduced daily milk yield by 1.32 kg or 9.46%, by 0.92 kg or 9.62% and by 1.27 kg or 9.48% as the THI values went from 64 in the spring, from 66 in the autumn and from 42.34 in the winter periods to 79 in the summer period. The adverse effect on daily milk yield was most likely mediated through reduction in the forage intake in the summer heat stress, which decreased by 1.63 kg or 9.58%, by 1.42 kg or 9.63% and by 1.25 kg or 9.67% compared to those in spring, autumn and winter, respectively, and changes that occurred in body temperature and plasma hormone concentrations. The reductions in voluntary intake and the subsequent declines in milk production are consistent responses to the heat stress in lactating dairy cows. The efficiency of conversion of feed to milk was higher ($P < 0.05$) for the heat-stressed cows (1.6 vs 1.59).

Table 2 Heat stress (THI) effect on milk yield, forage intake and food efficiency

Parameters	Seasons			
	Spring (THI 64.21)	Summer (THI 79.31)	Autumn (THI 66.36)	Winter (THI 42.34)
Milk yield, kg/day				
- Average	24.64a	23.32b	24.24c	24.59a
- Standard deviation	0.74	1.22	0.91	0.61
- Minimum	21.76	21.10	22.19	22.73
- Maximum	26.05	26.62	26.61	26.58
Forage intake, kg per cow/day				
- Average	39.30a	37.67b	39.09a	38.92a
- Standard deviation	1.74	0.96	1.42	1.44
- Minimum	34.70	35.28	36.35	35.62
- Maximum	42.08	39.84	42.10	41.59
Food efficiency, kg milk per kg food				
- Average	1.59a	1.61b	1.61b	1.58a
- Standard deviation	0.08	0.09	0.07	0.06
- Minimum	1.37	1.44	1.42	1.40
- Maximum	1.86	1.82	1.75	1.71

Means on the same row with the same letter are not significantly different ($P > 0.05$).

In Figures 2, 3 and 4, the relationships between temperature-humidity index (THI) and milk yield, feed intake and feed efficiency during the seasons in year are shown. As shown in Figure 2, there were linear and negative relationships between THI and daily milk yield in the spring, summer and autumn periods. This shows that milk production is a function of THI. The negative slope of the regression line indicates that milk production decreases as THI increases. The coefficient of linear regression (P < 0.01) of the THI index on milk yield was negative in spring (b = -0.011), summer (b = -0.108) and autumn (b = -0.046), which means that for every THI unit increase, milk yield decreases by 0.011 kg, 0.108 kg and 0.046 kg, respectively. The value of this relationship for predictive purposes is relatively high for summer and autumn, as depicted by an R^2. The coefficient of linear regression of the THI index on forage intake was negative in summer (b = -0.014) and autumn (b = -0.027), and statistically highly significant (P < 0.01) with R^2 being 0.006 and 0.041. Positive coefficient of linear regression of the THI index on food efficiency was in all seasons (b = 0.009 in spring, b = 0.006 in summer, b = 0.002 in autumn and b = 0.001 in winter). The obtained negative coefficient of linear regression of milk and forage intake and the positive coefficient of linear regression of food efficiency on THI indicate that milk yield and forage intake decrease and food efficiency increases as THI increases.

Discussion

The period from the beginning of May to the end of September was extraordinarily hot in the observed years. The obtained data are consistent with those of Bouraoui et al. (2002), which indicated the presence of heat stress in summer (average T and THI were 29.8 ± 2.5 and 78.0 ± 3.23) in 96% of the test days for this period. In the research of Lambertz et al. (2014) in Germany in 2011, the maximum THI values exceeded 72 from April to September. In the manuscript of Herbut and Angrecka (2012), the THI index ranged from 76 to 82, indicating that the animals living in this barn experienced moderate thermal stress. Throughout the experimental period, the highest temperature as well the maximum THI values were recorded in July. Such high results reveals that there was a risk to cows' lives (Broucek, 2009; Vitali et al., 2009). Akyuz et al. (2010) distinguishes three levels of thermal stress depending on the THI value: mild stress, 72-79; moderate stress, 79-89; and heavy stress, > 89. Relative humidity is compared to T, and THI has the opposite values throughout the year. To wit, with the increasing T and THI, there was a decrease in relative humidity; therefore, the lowest value was obtained in summer and the highest in winter. The obtained values were consistent with the values obtained by Lambertz et al. (2014).

Environmental factors such as temperature, relative humidity, solar radiation and air movement, and also their interactions, often limit the performance of dairy cows (West, 2003). Moreover, different housing systems might influence the effect of these environmental conditions on milk production (Lambertz et al., 2014).

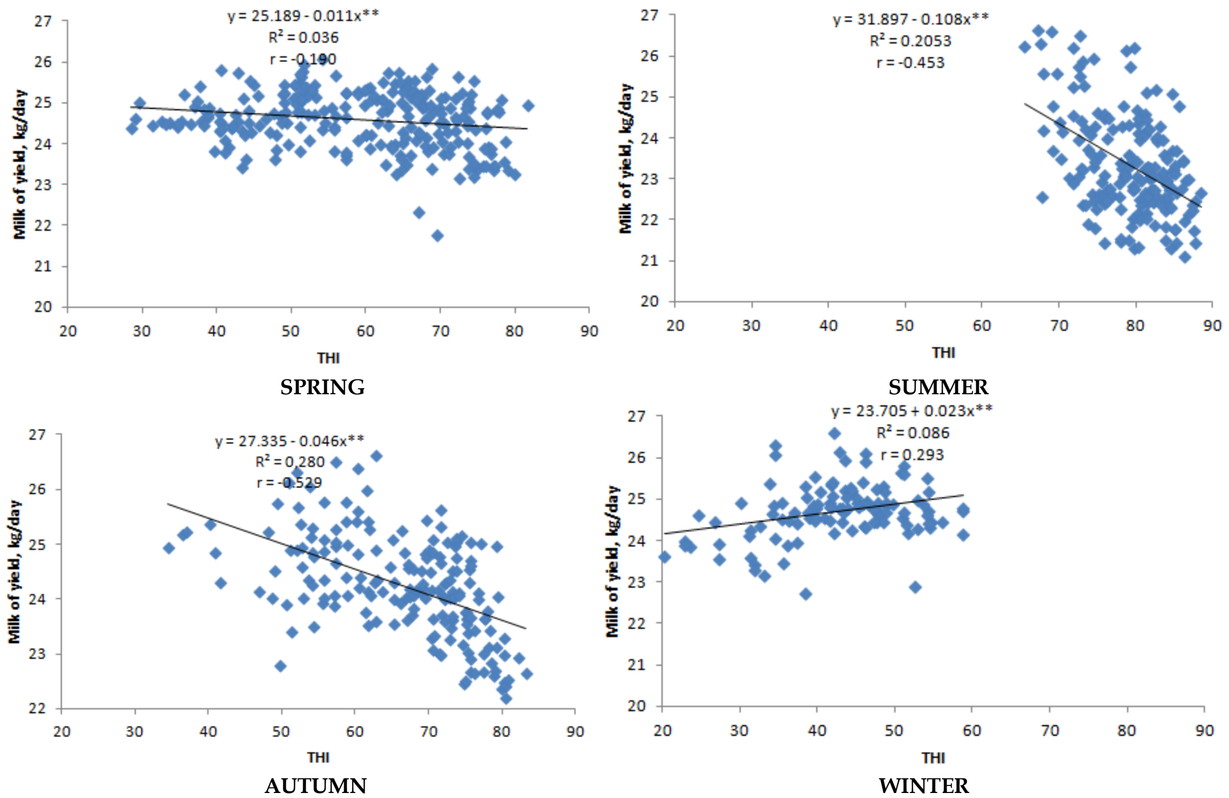

Figure 2 Relationship between temperature-humidity index (THI) and daily milk yield during the seasons in a year. **Regression coefficients are significant at P < 0.01. *Regression coefficients are significant at P < 0.05. R^2 = coefficient of determination. r = coefficient of correlation.

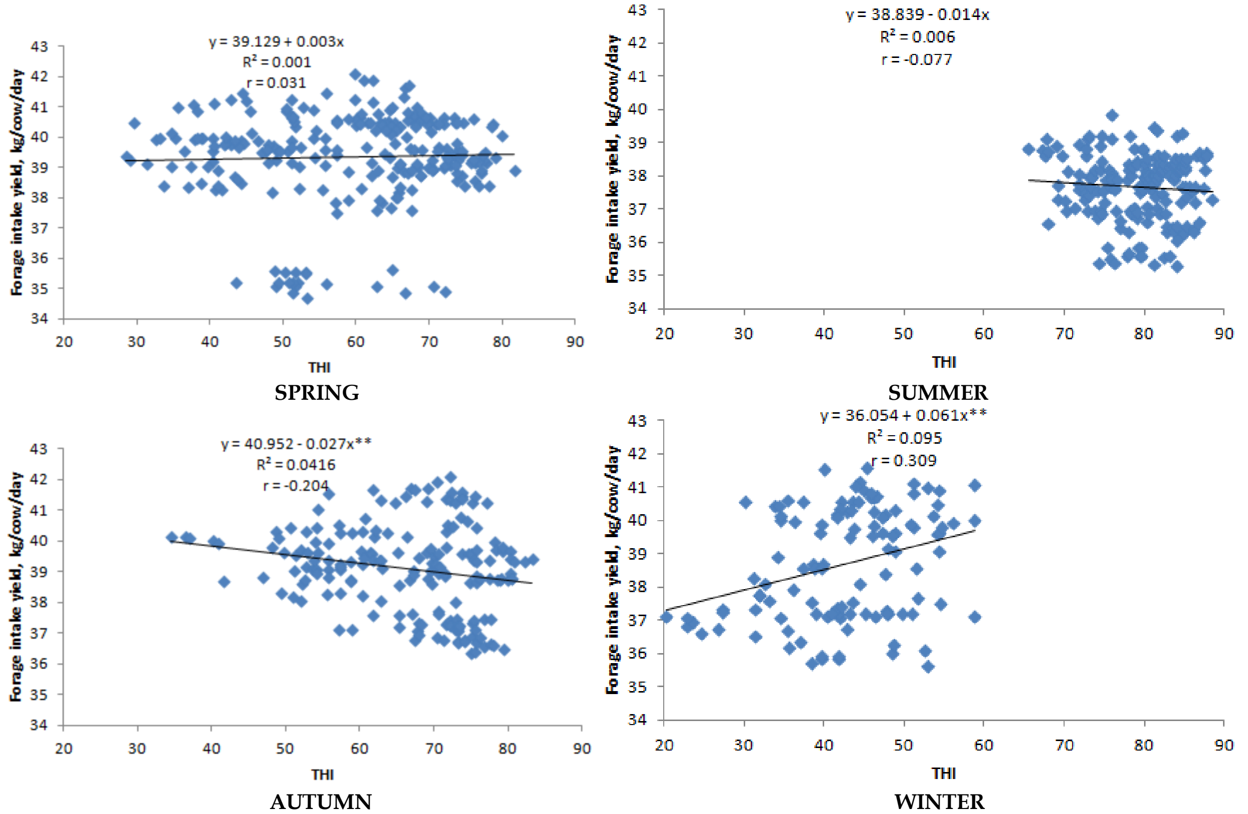

Figure 3 Relationship between temperature-humidity index (THI) and forage intake during the seasons in a year. **Regression coefficients are significant at $P < 0.01$. *Regression coefficients are significant at $P < 0.05$. R^2 = coefficient of determination. r = coefficient of correlation.

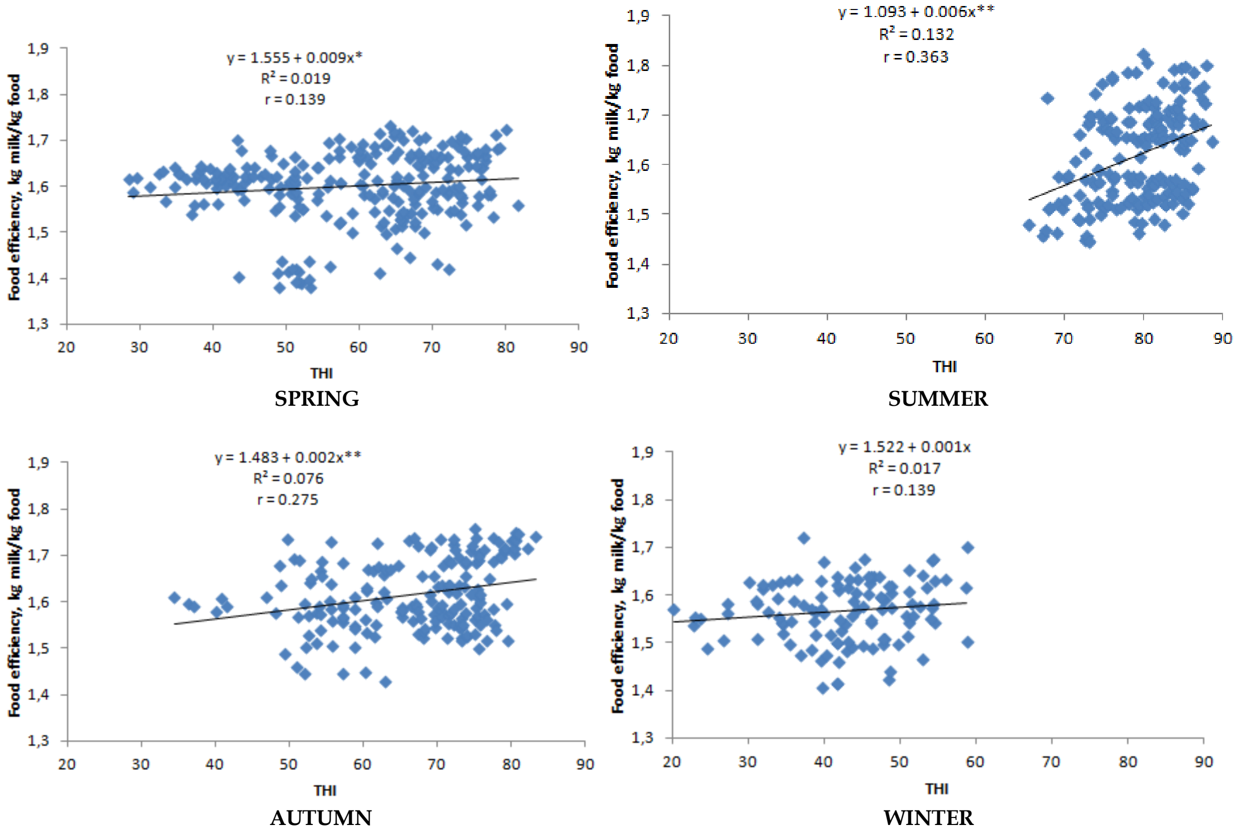

Figure 4 Relationship between temperature-humidity index (THI) and food efficiency during the seasons in a year. **Regression coefficients are significant at $P < 0.01$. *Regression coefficients are significant at $P < 0.05$. R^2 = coefficient of determination. r = coefficient of correlation.

Consistent with the results of the present study, Bouraoui et al. (2002) reported that heat stress reduced daily milk yield of cows while it increased the THI values. The authors concluded that a portion of the negative effects of heat stress on milk production could be explained by the decreased nutrient intake and decreased nutrient uptake by the portal drained viscera of the cows. The drop in daily milk production in our study (1.32 kg per day) was considerably higher than the 0.88 kg per day per cow reported by West (2003). The study of Collier et al. (2009) showed that the daily milk yield decreased around 2.2 kg/day when the THI values increased from 65 to 73. Bouraoui et al. (2002) showed that when the THI index increased from 68 to 78, the decline of milk yield production totaled 4 kg; and for every THI unit increase, to above 69, the daily milk yield per cow reduced 0.41 kg more. Falta et al. (2008) also found that for THI values above 72, milk yield decline of 4 kg occurred. In the study of Bouraoui et al. (2002) in Tunisia, the heat stress reduced daily milk yield by 3.98 kg and dry matter intakes by 1.73 kg; the THI values went from 68 in the spring period to 78 in the summer period.

West et al. (1999) suggest that rectal temperature is a sensitive indicator of thermal balance and may be used to assess the negative effects of hot environments on lactation of dairy cows. Long ago, in the study of Johnson et al. (1963), it was shown that a rise of 1°C or less in rectal temperature was enough to reduce the intake and production in dairy cows. To wit, Johnson et al. (1963) reported that milk yield declined when body temperature exceeded 38.9°C, and, for every 0.55°C increase in rectal temperature, milk yield and intake of total digestible nutriment declined by 1.8 and 1.4 kg, respectively. However, THI may describe more precisely the effect of environment on the cow's ability to dissipate heat.

In the research of Herbut and Angrecka (2012) in Poland, the increase in THI value led to the decrease in daily milk yield from 0.18 to 0.36 kg per THI unit. Ravagnolo and Misztal (2000) reported milk production decrease of 0.2 kg per THI unit, while West (2003) reported the loss of 0.88 kg milk per THI unit. The study of Bouraoui et al. (2002) showed that the daily milk yield decreased by 0.41 kg per THI unit. The drop in daily milk production in our study was lower than the 0.32 and 0.26 kg per cow reported by Ingraham et al. (1979). In Lower Saxony, Brügemann et al. (2012) calculated milk yield declines per THI unit, by 0.08 kg for regions with indoor systems and 0.17 kg for grazing based systems. In the study of Collier et al. (2009) in Arizona, the increase in THI value led to the decrease in daily milk yield of 0.13 kg per THI unit. Another important factor influencing the effects of heat stress on milk production is the stage of lactation. However, the results are controversial. Igono et al. (1992) and Novak et al. (2009) reported a greater decrease in early lactation than in mid or late lactation. Thereby, Novak et al. (2009) mentioned that cows in early lactation were more sensitive to the effect of heat than cows in late lactation.

Application of management interventions to ameliorate the effects of heat load on the performance of dairy cows could be necessary in certain periods of the year under climatic conditions. Appropriate housing facilities and equipment to protect dairy cows from climatic extremes are of significant importance for production maintenance. Cooling of cows by misting combined with air move should be used. Evaporative cooling is the best for protection against high temperature stress.

References

Aharoni Y, Ravagnolo O and Misztal I 2002. Comparison of lactational responses of dairy cows in Georgia and Israel to heat load and photoperiod. Anim Sci. 75(3): 469-476.

Akyuz A, Boyaci S and Cayli A 2010. Determination of critical period for dairy cows using temperature humidity index. J Anim Vet Adv. 9(3): 1824-1827.

Arjomandfar M, Zamiri MJ, Rowghani E, Khorvash M and Ghorbani G 2010. Effects of water desalination on milk production and several blood constituents of Holstein cows in a hot arid climate. Iranian J Vet Rese. 11(3): 233-238.

Bernabucci U, Lacetera NL, Baumgard H, Rhoads RP, Ronchi B and Nardone A 2010. Metabolic and hormonal acclimation to heat stress in domesticated ruminants. Anim. 4(7): 1167–1183.

Bohmanova J, Misztal I and Cole JB 2007. Temperature-humidity indices as indicators of milk production losses due to heat stress. J Dairy Sci. 90(4): 1947-1956.

Bouraoui R, Lahmar M, Majdoub A, Djemali M and Belyea R 2002. The relationship of temperature-humidity index with milk production of dairy cows in a Mediterranean climate. Anim Rese. 51(6): 479-491.

Bray DR, Bucklin RA, Shearer JK, Montoya R and Giesy R 1997. Reduction of environmental stress in adult and young dairy cattle in hot, humid climates. Proceedings of the Fifth international symposium (Bloomington, Minnesota) pp. 672-679.

Broucek J, Novák P, Vokřálová J, Šoch M, Kišac P and Uhrinčať M 2009. Effect of high temperature on milk production of cows from free-stall housing with natural ventilation. Slovak J Anim Sci. 42: 167-173.

Brown-Brandl TM, Nienaber JA, Eigenberg RA, Freetly HC and Hahn GL 2003. Thermoregulatory responses of feeder cattle. J Thermal Biol. 28(2): 149-157.

Brügemann KE, Gernand U, König von B and König S 2012. Defining and evaluating heat stress thresholds in different dairy cow production systems. Arc Tierzucht. 55(1): 13-24.

Collier RJ, Zimbelman RB, Rhoads RP, Rhoads ML and Baumgard LH2009. A Re-evaluation of the Impact of Temperature Humidity Index (THI) and Black Globe Humidity Index (BGHI) on Milk Production in High Producing Dairy Cows. Proceedings of 24th Western Dairy Management Conference (S Virginia) pp: 113-125.

Correa-Calderon A, Armstrong D, Ray D, Denise S, Enns M and Howison C 2004. Thermoregulatory responses of Holstein and Brown Swiss heat-stressed dairy cows to two different cooling systems. Internat. J Biomet. 48(3): 142-148.

Dikmen S and Hansen PJ 2008. Is the temperature-humidity index the best indicator of heat stress in lactating dairy cows in a subtropical environment? J Dairy Sci. 92(1): 109-116.

Du Preez JH, Giesecke WH and Hattingh PJ and 1990. Heat stress in dairy cattle and other livestock under Southern African conditions. I.

Temperature-humidity index mean values during the four main seasons. J Vet Rese. 57(1): 77-86

Falta D, Walterova L, Skypala M and Ghladek G 2008. Effect of stable microclimate on milk production of Holstein cows on the 2nd and 3rd lactation. Anim Welfare. 4: 104-110.

Ghavi Hossein-Zadeh N, Mohit A and Azad N 2013. Effect of temperature-humidity index on productive and reproductive performances of Iranian Holstein cows. Iranian J Vet Rese. 14(2): 106-112.

Hahn GL and Mader TL 1997. Heat waves in relation to thermoregulation, feeding behavior and mortality of feedlot cattle. Proceedings of the 5th International Symposium (Bloomington, Minnesota) pp: 563-571.

Herbut P and Angrecka S 2012: Forming of temperature-humidity index (THI) and milk production of cows in the free-stall barn during the period of summer heat. Anim Sci Papers and Reports. 30(4): 363-372.

Hulme PH 2005. Adapting to climate change: Is there scope for ecological management in the face of a global threat. J Applied Ecol. 42(5): 784-794.

Igono MO, Bjotvedt G and Sanford-Crane HT 1992. Environmental profile and critical temperature effects on milk production of Holstein cows in desert climate. Internat J Biomet. 36(2):77-87.

Ingraham RH, Stanley RW and Wagner WC 1979. Seasonal effect of the tropical climate on shaded and nonshaded cows as measured by rectal temperature, adrenal cortex hormones, thyroid hormone, and milk production. American J Vet Rese. 40(12): 1792-1797.

Johnson HD, Ragsdale AC, Berry IL and Shanklin MD 1963. Temperature-humidity effects including influence of acclimation in fed and water consumption of Holstein cattle. University of Missouri, Research Bulletin, p. 846.

Lambertz C, Sanker C and Gauly M 2014. Climatic effects on milk production traits and somatic cell score in lactating Holstein-Friesian cows in different housing systems. J Dairy Sci. 97(1): 319-329.

Mader TL, Davis MS and Brown-Brandl T 2006. Environmental factors influencing heat stress in feedlot cattle. J Dairy Sci. 84(3): 712-719.

Nardone A, Ronchi B, Lacetera N and Bernabucci U 2006. Climatic effects on productive traits in livestock. Vet. Rese. Communicat. 30(Suppl. 1): 75-81.

Novak P, Vokralova J and Broucek J 2009. Effects of the stage and number of lactation on milk yield of dairy cows kept in open barn during high temperatures in summer months. Arch Tierzucht. 52: 574-586.

NRC 1971. A Guide to Environmental Research on Animals. NRC, National Academy of Sciences, Washington, DC.

Ravagnolo O and Misztal I 2000. Genetic Component of Heat Stress in Dairy Cattle, Parameter Estimation. J Dairy Sci. 83: 2126-2130.

SAS Institute. 2008. SAS/STAT® 9.2. User's Guide. SAS Institute Inc., Cary, NC

Scholtz MM, Mc Manus C, Leeuw KJ, Louvandini H, Seixas L, de Melo CB, Theunissen A and Neser FWC 2013. The effect of global warming on beef production in developing countries of the southern hemisphere. Natural Sci. 5: 106-119.

Silva RG 2000. Introducao a bioclimatalogia animal. Sao Paulo.

Spiers DE, Spain JN, Sampson JD and Rhoads RP 2004. Use of physiological parameters to predict milk yield and feed intake in heat-stressed dairy cows. J Thermal Bio. 29(7-8): 759-764.

Vitali A, Segnalini M, Berocchi L, Bernabucci U, Nardone A and Lacetera N 2009. Seasonal pattern of mortality and relationships between mortality and temperature-humidity index in dairy cows. J Dairy Sci. 92(8): 3781-3790.

West JW 1999. Nutritional strategies for managing the heat – stressed dairy cow. J Anim Sci. 77(Suppl. 2): 21-35.

West JW, Mu Llinix BG and Bernard JK 2003. Effects of Hot, Humid Weather on Milk Temperature, Dry Matter Intake and Milk Yield of Lactating Dairy Cows. J Dairy Sci. 86(1): 232-242.

บทคัดย่อ

ความสัมพันธ์ของดัชนีอุณหภูมิและความชื้นต่อการผลิตน้ำนมและการกินอาหารในวัวนม โฮลสไตล์ ฟรีเชียน ในแต่ละฤดูกาล

ทิโบ โคนีเยฟ[1] เนโบซา เซโควิค[2] เนอจิน เมมิสิ[3] ดาโกเมีย ลูกัส[1] นิโคลา ปูวากา[4]*
มิลาน สโตซิน[1] อันดาส ฮาลาส[5] บรานิสราฟ มิสเซวิค[1]

วัตถุประสงค์ของการศึกษาครั้งนี้ เพื่อประเมินความสัมพันธ์ของดัชนีอุณหภูมิและความชื้นต่อการผลิตน้ำนม การกินอาหาร และประสิทธิภาพการเปลี่ยนอาหาร ในวัวนมโฮลสไตล์ ฟรีเชียน ในแต่ละฤดูกาล โดยศึกษาในแม่วัวในช่วงระยะเวลา 2 ปี จำแนกเป็นฤดู ใบไม้ผลิ จำนวน 560 ตัว ฤดูร้อนจำนวน 557 ตัว ฤดูใบไม้ร่วงจำนวน 594 ตัว และฤดูหนาวจำนวน 567 ตัว ซึ่งในฤดูร้อนจะมีค่าอุณหภูมิและความชื้นเฉลี่ย สูงกว่า 25°C และ ค่าดัชนี 72 ทำให้แม่วัวได้รับภาวะเครียดจากความร้อนในช่วงฤดูร้อน ผลการศึกษาพบว่าในฤดูร้อน ภาวะเครียดจากความร้อนทำให้น้ำนมโคลดลง 1.32 กิโลกรัม หรือ 9.46% จากฤดูใบไม้ผลิ (ค่าดัชนี 64) และลดลง 0.92 กิโลกรัม หรือ 9.62% จากฤดูใบไม้ร่วง (ค่าดัชนี 66) และลดลง 1.27 กิโลกรัม หรือ 9.48% จากฤดูหนาว (ค่าดัชนี 42) เมื่อเปรียบเทียบกับฤดูร้อน (ค่าดัชนี 79) และพบว่าในฤดูร้อนการกินอาหารลดลง 1.63, 1.42, และ 1.25 กิโลกรัม เมื่อเปรียบเทียบกับฤดูใบไม้ผลิ ฤดูใบไม้ร่วง และฤดูหนาว ตามลำดับ ในขณะที่ประสิทธิภาพการเปลี่ยนอาหารเป็นนมเพิ่มขึ้นจาก 1.6 เป็น 1.59 ต่อน้ำนม 1 กิโลกรัม ผลการศึกษานี้แสดงให้เห็นความสัมพันธ์ เมื่อค่าดัชนีอุณหภูมิและความชื้นสูงขึ้น จะมีน้ำนมโคลดลง การกินอาหารลดลง ประสิทธิภาพการเปลี่ยนอาหารเพิ่มขึ้น โดยสรุปภาวะเครียดในฤดูร้อน มีผลลบต่อผลผลิตน้ำนม และการกินอาหารในวัวนม ดังนั้นจึงมีความจำเป็นต้องมีการจัดการฟาร์มที่ดี เพื่อลดภาวะเครียดจากความร้อน เพื่อให้ได้ผลผลิตที่เหมาะสม

คำสำคัญ: อุณหภูมิ ความชื้นสัมพัทธ์ การผลิตน้ำนม การกินอาหาร

[1]มหาวิทยาลัยจอห์นไนสบิทท์เบลเกรด คณะไบโอฟาร์มมิง มาสารา ทิทา 39 บัคคา โทโปลา ประเทศเซอร์เบีย
[2]คณะเกษตรและเทคโนโลยีการอาหาร ซิลิลา เมโทดิจา โปรคูลี ประเทศเซอร์เบีย
[3]โรงงานผลิตนมซูโบติกา โทมินสกา 10 ซูโบติกา ประเทศเซอร์เบีย
[4]มหาวิทยาลัยโนวิซัส คณะเกษตรศาสตร์ ที โดสิเทจา โอบาโดวิกา 8 โนวิซัส ประเทศเซอร์เบีย
สิทธิบัตร วาลเด เซ็ตโควิกา 1a มิสสิเซโว ประเทศเซอร์เบีย
[5]มหาวิทยาลัย เซ็นต์ อิสแวน คณะเกษตรศาสตร์และวิทยาศาสตร์สิ่งแวดล้อม ปาเตอร์ คาโรลี่ 1 โกโดโล ประเทศฮังการี
***ผู้รับผิดชอบบทความ** *E-mail: dragomirlukac@gmail.com*