THE VARIABILITY OF MICROCLIMATE PARAMETERS IN DAIRY CATTLE FARM FACILITY

Gantner, Vesna; Šinka, D.; Popović, V.; Ćosić, M.; Sudarić, Tihana; Gantner, Ranko

Source / Izvornik: **International Scientific Conference, Sustainable agriculture and rural development III: book of proceedings, 2023, 77 - 86**

Conference paper / Rad u zborniku

Publication status / Verzija rada: **Published version / Objavljena verzija rada (izdavačev PDF)**

Permanent link / Trajna poveznica: https://urn.nsk.hr/urn:nbn:hr:151:803957

Rights / Prava: In copyright / Zaštićeno autorskim pravom.

Download date / Datum preuzimanja: **2025-01-31**

Sveučilište Josipa Jurja Strossmayera u Osijeku
Fakultet agrobiotehničkih znanosti Osijek

Repository / Repozitorij:

Repository of the Faculty of Agrobiotechnical Sciences Osijek - Repository of the Faculty of Agrobiotechnical Sciences Osijek

DIGITALNI AKADEMSKI ARHIVI I REPOZITORIJI

THE VARIABILITY OF MICROCLIMATE PARAMETERS IN DAIRY CATTLE FARM FACILITY

Vesna Gantner,[1] *Danko Šinka*[2], *Vera Popović*[3], *Milivoje Ćosić*[4], *Tihana Sudarić*[5], *Ranko Gantner*[6]

Abstract

Since the change in climate is unquestionable if we plan to have sustainable milk production we need to implement a long-term mitigation method. A precondition for the genetic evaluation and selection of genetically heat-resistant animals is the measurement and analysis of the variability of microclimate parameters. Therefore, this research aimed to show the variability of microclimate parameters in a selected dairy cattle farm. The records of ambient temperature and relative humidity in the selected farm were measured using a Datalogger. The conducted research and data analysis indicate noticeable variability of observed microclimate parameters (ambient temperature, relative humidity and temperature-humidity index) in regard to the measurement days. Determined daily THI values indicate a high probability of the occurrence of heat stress in the observed period. Furthermore, daily monitoring of microclimate parameters enables timely reaction and prevention of more serious consequences of heat stress on dairy cows.

Key words: *dairy cattle, microclimate, heat stress*

---

1 Prof. *Vesna Gantner*, Ph.D., Full professor, J. J. Strossmayer University of Osijek, Faculty of Agrobiotechnical Sciences Osijek, Vladimira Preloga 1, Osijek, Croatia; e-mail: vgantner@fazos.hr

2 *Danko Šinka*, PIK-VINKOVCI plus Ltd., Matije Gupca 130, Vinkovci, Croatia, e-mail: danko4osijek@gmail.com

3 Prof. *Vera Popović*, Ph.D., Principal research fellow, Institute of Field and Vegetable Crops, Maksima Gorkog 30, Novi Sad, Serbia, e-mail: vera.popovic@ifvcns.ns.ac.rs

4 Prof. *Milivoje Ćosić,* Ph.D., Institute of Forestry, Kneza Višeslava 3, 11030 Belgrade, Serbia; e-mail: mickocosic@gmail.com

5 Prof. *Tihana Sudarić*, Ph.D., Full professor, Full professor, J. J. Strossmayer University of Osijek, Faculty of Agrobiotechnical Sciences Osijek, Vladimira Preloga 1, Osijek, Croatia; e-mail: tsudaric@fazos.hr

6 Prof. *Ranko Gantner*, Ph.D., Associate professor, J. J. Strossmayer University of Osijek, Faculty of Agro-biotechnical Sciences Osijek, Vladimira Preloga 1, Osijek, Croatia; e-mail: rgantner@fazos.hr

Introduction

The changes in climate, worldwide, become one of the most pronounced problems in agricultural production, especially in livestock production. Climate change threatens the global food supply since many crops have lower yields due to the occurrence of extreme weather events; droughts, floods, higher temperatures etc. (Popović et al., 2015, 2020). Furthermore, Gauly et al. (2013) pointed out that in Europe heat stress becomes a growing problem in total livestock production and especially in dairy cattle breeding. Accordingly, to the report of IPCC (2007) changes in climate will result in increasingly adverse climatic conditions for all sectors of food production (plant and animal). Based on their research, Reiczigel et al. (2009) in Hungary, and Dunn et al. (2014) in the UK determined the increase in the occurrence of heat stress days per year. Almeida et al. (2011) emphasized that the optimal temperature of the environment in dairy production depends on the selected species, the animal's breed, the amount and quality of consumed feed, age (parity), individual capability of acclimatization, animal's productivity, the characteristics of coat and fur and also on individual animal tolerance to environmental conditions (high or low temperatures). Furthermore, Santos Daltro et al. (2017) concluded that high-producing dairy cows are more susceptible to heat stress. They explained that with the increase in milk production, also the production of animals' metabolic heat is increased. Vasconcelos and Demetrio (2011) pointed out that the selection for high milk production decreases the capability of the cow to resist the heat stress caused. The same authors concluded that therefore in dairy cows during the months with higher temperatures, susceptibility to heat stress increases while the milk production and reproductive efficiency decreases. Likewise, Hansen (2013) noted that the elevated milk production causes dairy cows to be more sensitive to heat stress conditions suggesting that heat stress will become a huge problem in intensive dairy farming regardless the climate changes. Furthermore, Bohmanova (2006) and Collier et al. (2006) indicated that animal productivity considerably modifies the animal reaction to heat stress causing high-production animals are more susceptible to heat stress than animals with lower milk production. Different studies (Bouraoui et al., 2002; West, 2003; Spiers et al., 2004; Upadhyay et al., 2009; Wheelock et al., 2010; Gantner et al. 2011, 2017) pint out that the environment characterized by heat stress adversely affects the quantity and quality of milk in dairy animals, particularly in animals of high breeding value. Moreover, accordingly, to NRC (2007) dairy animals in heat-stress conditions also have increased energy requirements for maintenance for 30%. Fur-

Downloaded from https://cabidigitallibrary.org by 161.53.194.20, on 07/01/24.
Subject to the CABI Digital Library Terms & Conditions, available at https://cabidigitallibrary.org/terms-and-conditions

thermore, Das et al. (2016) determined that heat stress also affects animals' health due to changes in physiology, metabolism, hormonal and immunity system. Based on all stated, heat stress generates a substantial loss of profit for dairy farms (St-Pierre et al., 2003).

Heat stress represents a combination of ambient temperature and humidity that overreach the animal's comfort zone. The standard measure of heat stress in dairy farming is the temperature-humidity index (THI) which incorporates data regarding the ambient temperature and relative humidity (Kibler, 1964). The value of the THI at which heat stress impacts milk production and feed intake range from 68 to 72 (Du Preez et al., 1990a, b; Bouraoui et al., 2002; Bernabucci et al., 2010; Gantner et al., 2011; Collier end Hall, 2012). There are various methods for the reduction of the heat stress effect in dairy farming. Short-term methods refer to feeding management and the usage of diverse cooling systems in farm facilities, while long-term methods mean the selection of animals resistant to heat stress. Since the change in climate are no longer questionable if we plan to have sustainable milk production we need to implement a long-term reduction method. A precondition for the genetic evaluation and selection of genetically heat-resistant animals is the measurement and analysis of the variability of microclimate parameters. Therefore, this research aimed to show the variability of microclimate parameters in selected dairy cattle farm.

Material and Methods

The records of ambient temperature and relative humidity in selected production facility of the dairy cattle farm were measured on daily basis every 5 minutes using a Datalogger. Furthermore, the data was stored on a weekly basis in a central server for further analytical processing. For the analysis of the variability of microclimate parameters (ambient temperature, relative humidity and temperature-humidity index), records of microclimate parameters measured in the period from 15.05.2022 until 30.08.2022 were used. Based on measured microclimate parameters, the temperature-humidity index (THI) was calculated using the following equation by Kibler (1964):

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

Downloaded from https://cabidigitallibrary.org by 161.53.194.20, on 07/01/24.
Subject to the CABI Digital Library Terms & Conditions, available at https://cabidigitallibrary.org/terms-and-conditions

Where:

Ta - the average temperature in degrees Celsius,

RH - the relative humidity as a fraction of the unit.

The basic variability of analysed traits is presented in Table 1.

Table 1. *Basic statistical parameters of the analysed traits*

Measuring month	Temperature, °C			Relative humidity, %			THI		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
5	21.5	4.00	18.550	63.4	15.17	23.930	67.8	5.00	7.380
6	25.1	3.64	14.494	65.5	14.49	22.131	73.1	4.10	5.615
7	25.9	4.18	16.123	52.2	14.08	26.964	72.7	4.44	6.112
8	25.0	3.99	15.938	67.5	20.57	30.472	72.9	3.86	5.303
Total	24.8	4.19	16.898	61.9	17.64	28.475	72.1	4.64	6.437

The variability of microclimate parameters in the selected production facility is shown as an average, minimum and maximum value per day separately for each month and measurement day.

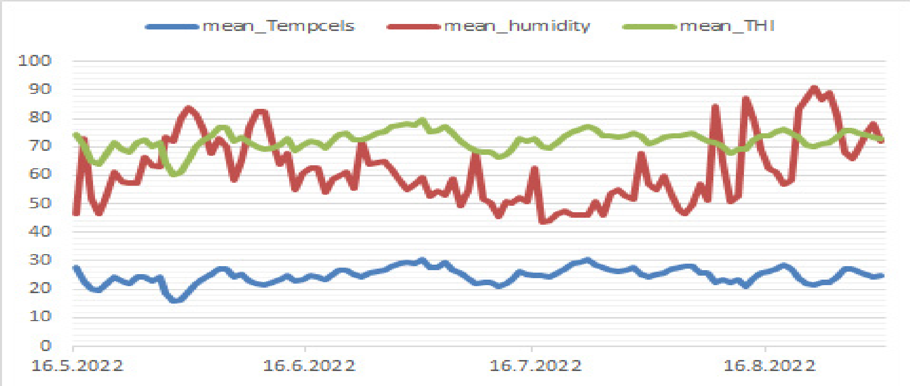
Logical control of data base and statistical analysis was carried out in the statistical program SAS/STAT (SAS Institute Inc., 2000). Furthermore, MS Excel was used for the graphic presentation of the data.

Results and discussion

The variability of average daily values of microclimate parameters in the selected facility is shown in Figure 1. Mean values of daily ambient temperatures ranged from 15.84 to 30.42°C. The mean values of daily relative humidity ranged from 43.52 to 91.10, while the mean values of the daily temperature-humidity index ranged from 60.04 to 79.72. The determined mean values of daily ambient temperatures and the daily temperature-humidity index indicate the occurrence of heat stress in the animals in the selected facility. Since highly productive dairy cows lose thermoregulation ability at temperatures higher than 25°C, a decrease in daily milk production on this farm is expected.

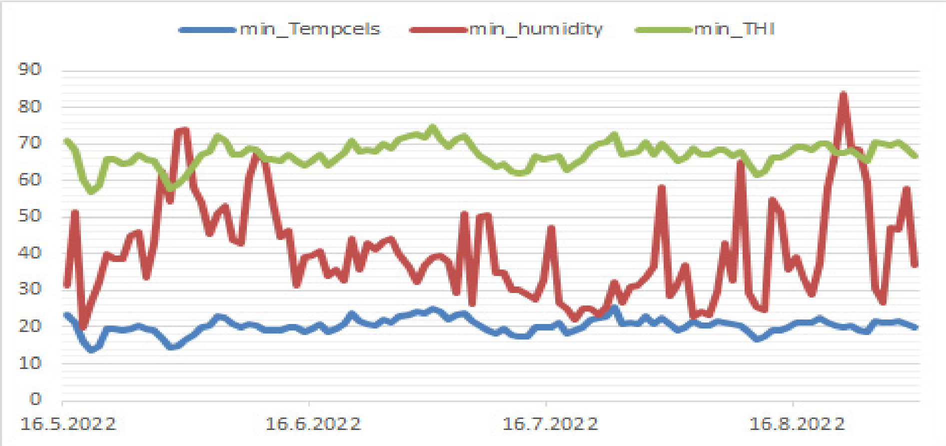
Downloaded from https://cabidigitallibrary.org by 161.53.194.20, on 07/01/24.
Subject to the CABI Digital Library Terms & Conditions, available at https://cabidigitallibrary.org/terms-and-conditions

Figure 1. *Variability of average daily values of microclimate parameters (Tempcels – ambient temperature in °C; humidity – relative humidity; THI – temperature-humidity index)*



The variability of minimal daily values of microclimate parameters in the selected facility is shown in Figure 2. Minimal values of daily ambient temperatures ranged from 13.84 to 25.50°C. The minimal values of daily relative humidity ranged from 19.80 to 83.80, while the minimal values of the daily temperature-humidity index ranged from 50.03 to 74.72. Given that THI values above 68 Collier et al. (2012) cause heat stress in dairy cows, even determined minimum values of the daily temperature-humidity index indicate the occurrence of heat stress.

Figure 2. *Variability of minimal daily values of microclimate parameters (Tempcels – ambient temperature in °C; humidity – relative humidity; THI – temperature-humidity index).*

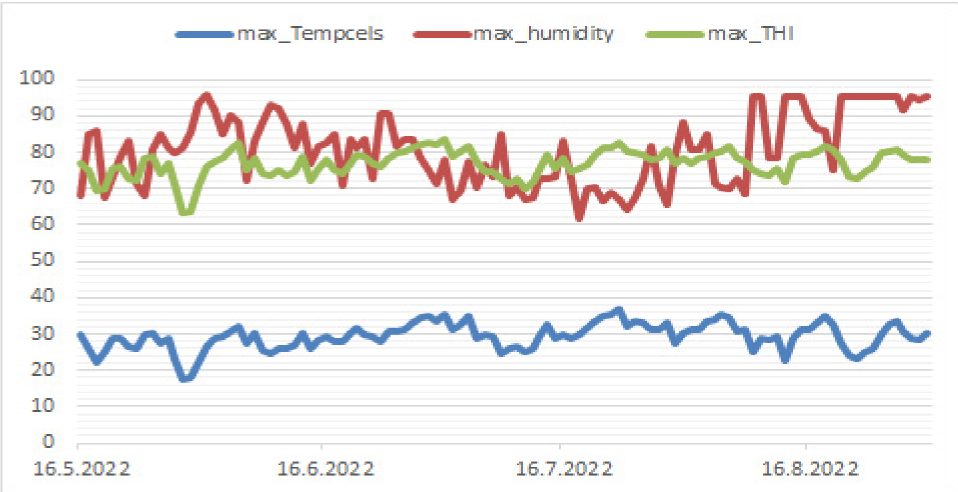


Downloaded from https://cabidigitallibrary.org by 161.53.194.20, on 07/01/24.
Subject to the CABI Digital Library Terms & Conditions, available at https://cabidigitallibrary.org/terms-and-conditions

The changes in maximal daily values of microclimate parameters in the selected facility are shown in Figure 2. Maximal values of daily ambient temperatures vary in the interval from 17.70 to 36.90°C, while the maximal values of daily relative humidity vary from 61.90 to 96.00. The maximal values of the daily temperature-humidity index vary from 63.13 to 83.66.

If we analyse the maximum values of the observed parameters, it is evident that the cows in the selected facility were under heat stress for most of the observed period. Accordingly, to other research, heat stress is manifested when the THI of the environment exceed 68 (Collier et al., 2012; Bernabucci et al., 2010; Bouraoui et al., 2002; Du Preez et al., 1990a, b). Vitali et al. (2009) concluded that dairy cows are at increased risk of death in facilities where THI reaches 80.

Figure 3. *Variability of maximal daily values of microclimate parameters (Tempcels – ambient temperature in °C; humidity – relative humidity; THI – temperature-humidity index).*



In the following research, it is important to determine which factor has the most pronounced effect, the maximum temperature and the temperature-humidity index or the cumulative sum of individual measurements of those two parameters.

Conclusion

The conducted research and data analysis indicate noticeable variability of observed microclimate parameters (ambient temperature, relative humidity

Downloaded from https://cabidigitallibrary.org by 161.53.194.20, on 07/01/24.
Subject to the CABI Digital Library Terms & Conditions, available at https://cabidigitallibrary.org/terms-and-conditions

and temperature-humidity index) in regard to the measurement days. Average daily THI values ranged from 60 to 70, maximum daily THI values ranged from 63 to 84, and minimum daily THI values ranged from 57 to 75. Determined daily THI values indicate a high probability of the occurrence of heat stress in the observed period. Furthermore, daily monitoring of microclimate parameters enables timely reaction and prevention of more serious consequences of heat stress on dairy cows.

In the subsequent research, it is necessary to determine which factor has the most pronounced effect, the maximum temperature and the temperature-humidity index or the accumulation of individual measurements of those two parameters.

Literature

1. Almeida G.L.P., Pandorfi H., Guiselini C. (2011), *Uso do Sistema de resfriamento adiabático evaporativo no conforto térmico de vacas da raça Girolando*. Revista Brasileira de Engenharia Agrícola e Ambiental 15:754-760.

2. Bernabucci U., Lacetera N., Baumgard L. H., Rhoads R.P., Ronchi B., Nardone A. (2010), *Metabolic and hormonal acclimation to heat stress in domestic ruminants*. Animal, 4, 1167-1183.

3. Bohmanova J. (2006), *Studies on genetics of heat stress in US Holsteins*. PhD thesis. Athens: University of Georgia.

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

5. Collier R.J., Dahl G. E., Van Baale M. J. (2006): *Major advances associated with environmental effects on dairy cattle*. Journal of Dairy Science, 89, 1244-1253.

6. Collier R. J., Hall L.W. (2012): *Quantifying heat stress and its imp act on metabolism and performance*. Tucson, Arizona: Department of Animal Sciences, University of Arizona.

7. Das R., Sailo L., Verma N., Bharti P., Saikia J., Imtiwati, Kumar R. (2016): *Impact of heat stress on health and performance of dairy animals: A review*. Veterinary World, 9(3): 260-268.

Downloaded from https://cabidigitallibrary.org by 161.53.194.20, on 07/01/24.
Subject to the CABI Digital Library Terms & Conditions, available at https://cabidigitallibrary.org/terms-and-conditions

8. Du Preez J.H., Giesecke W. H., Hattingh P. J. (1990a): *Heat stress in dairy cattle and other livestock under Southern African conditions. I. Temperature-humidity index mean values during the four main seasons*. Onderstepoort Journal of Veterinary Research, 57, 77-86.

9. Du Preez J. H., Hatting P. J., Giesecke W. H., Eisenberg B.E. (1990b): *Heat stress in dairy cattle and other livestock under Southern African conditions. III. Monthly temperature-humidity index mean values and their significance in the performance of dairy cattle*. Onderstepoort Journal of Veterinary Research, 57, 243-248.

10. Dunn R. J. H., Mead N.E., Willett K.M., Parker D. E. (2014): *Analysis of heat stress in UK dairy cattle and impact on milk yields*. Environmental Research Letters 9, 064006.

11. Gantner V., Bobić T., Gantner R., Gregić M., Kuterovac K., Novaković J., Potočnik K. (2017): *Differences in response to heat stress due to production level and breed of dairy cows*. International Journal of Biometeorology 61, 9, 1675- 1685.

12. Gantner V., Mijić P., Kuterovac K., Solić D., Gantner R. (2011). *Temperature-humidity index values and their significance on the daily production of dairy cattle*. Mljekarstvo, 61(1), 56- 63.

13. Gauly M., Bollwein H., Breves G., Brügemann K., Dänicke S., Das, Demeler J.G., Hansen H., Isselstein J., König S., Lohölter M., Martinsohn M., Meyer U., Potthoff M., Sanker C., Schröder B., Wrage N., Meibaum B., Von Samson-Himmelstjerna G., Stinshoff H., Wrenzycki C. (2013*): Future consequences and challenges for dairy cow production systems arising from climate change in Central Europe—A review*. Animal, 7, 843-859.

14. Hansen P.J. (2013): *Genetic control of heat stress in dairy cattle*. In: Proceedings 49th Florida Dairy Production Conference, Gainesville, April 10, 2013.

15. Intergovernmental panel on climate change – IPCC (2007): Climate change 2007: *The physical science basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Downloaded from https://cabidigitallibrary.org by 161.53.194.20, on 07/01/24.
Subject to the CABI Digital Library Terms & Conditions, available at https://cabidigitallibrary.org/terms-and-conditions

16. Kibler H.H. (1964): *Environmental physiology and shelter engineering*. LXVII. Thermal effects of various temperature-humidity combinations on Holstein cattle as measured by eight physiological responses. Research Bulletin, University of Missouri, College of Agriculture, Agricultural Experiment Station, 862.

17. NRC. (2007): *Nutrient Requirements of Small Ruminants, Sheep, Goats, Cervids, and New World Camelids*. National Academy Press, Washington, DC.

18. Popović V. (2015). *The concept, classification and importance of biological resources in agriculture*. (Ed) Milovanovic J., Đorđević S.: Conservation and enhancement of biological resources in the service of ecoremediation. Monograph. Belgrade. ISBN 978-86-86859-41-9; 29-51; 1-407.

19. Popović V., Jovović Z., Marjanović-Jeromela A., Sikora V., Mikić S., Bojovic R., Lj. Šarčević Todosijević (2020): *Climatic change and agricultural production*. GEA (Geo Eco-Eco Agro) Inter. Conference, Podgorica; 27-31.05.2020, p. 160-166.

20. Reiczigel J., Solymosi N., Könyves L., Maróti-Agóts A., Kern A., Bartyik J. (2009): *Examination of heat stress caused milk production loss by the use of temperature-humidity indices*. Magy Allatorv, 131: 137-144.

21. Santos Daltro D., Fischer V., München Alfonzo E.P., Calderaro Dalcin V., Tempel Stumpf M., Kolling G. J., Marcos Vinícius Gualberto Barbosa Da Silva, Mcmanus C. (2017): *Infrared thermography as a method for evaluating the heat tolerance in dairy cows*. Revista Brasileira de Zootecnia / Brazilian Journal of Animal Science, 46(5), 374-383.

22. SAS Institute Inc. (2000). SAS User's Guide, version 8.2 ed. Cary, NC: SAS Institute Inc.

23. Spiers D. E., Spain J. N., Sampson J. D., Rhoads R.P. (2004), *Use of physiological parameters to predict milk yield and feed intake in heat-stressed dairy cows*. Journal of Thermal Biology, 29(7-8): 759-764.

24. St-Pierre N.R., Cobanov B., Schnitkey G. (2003): *Economic loses from heat stress by US livestock industries*. Journal of Dairy Science, 86, 52–77.

Downloaded from https://cabidigitallibrary.org by 161.53.194.20, on 07/01/24.
Subject to the CABI Digital Library Terms & Conditions, available at https://cabidigitallibrary.org/terms-and-conditions

25. Upadhyay R.C., Ashutosh, Singh S.V. (2009): *Impact of climate change on reproductive functions of cattle and buffalo*. In: Aggarwal, P.K., editor. Global Climate Change and Indian Agriculture. ICAR, New Delhi. 107-110.

26. Vasconcelos J. L. M., Demetrio D. G. B. (2011), *Manejo reprodutivo de vacas sob estresse calórico*. Revista Brasileira de Zootecnia 40:396-401.

27. Vitali A., Sagnalini M., Bertocchi L., Bernabucci U., Nardone A., Lacetera N. (2009): Seasonal pattern of mortality and relationships between mortality and temperature humidity index in dairy cows. Journal of Dairy Science, 92, 3781-3790.

28. West J. W. (2003): *Effects of heat-stress on production in dairy cattle*. Journal of Dairy Science, 86(6): 2131-2144.

29. Wheelock J. B., Rhoads R. P., Van Baale M. J., Sanders S.R., Baumgard L.H. (2010): *Effect of heat stress on energetic metabolism in lactating Holstein cows*. Journal of Dairy Science, 93(2): 644-655.

Downloaded from https://cabidigitallibrary.org by 161.53.194.20, on 07/01/24.
Subject to the CABI Digital Library Terms & Conditions, available at https://cabidigitallibrary.org/terms-and-conditions