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The Effect of Environmental Cooling Rate and Temperature-Humidity Index on the Milk Yield of Holstein Cattle on a Specific Farm

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Abstract

The objective of this work was to assess the effect of environmental cooling rate and temperature-humidity index on the milk yield of Holstein cattle on a specific farm. The experiment took place at a university farm (South Moravia) in the summer of 2017 and lasted over one month. The cows with the highest production have been chosen for this study since these cows have been suspected to be affected by heat stress more than the low-producing ones. The Environmental cooling rate (ECR) was measured by Hill´s thermometer and later calculated according to a formula. The temperature-humidity index (THI) was calculated from temperature and humidity data obtained by a data logger placed in the stable. Milk yield data were obtained directly from the milk parlour. The results show that the ECR is in a weak positive relationship (r= 0.07) with the milk yield. On the contrary, the THI showed moderate negative relation to the milk yield (r= -0.14).

Key words: environmental cooling rate, Holstein cattle, heat stress, THI, milk yield

Introduction

Heat stress is a forthcoming problem in agriculture. Not only will plant production and drought be a challenge for modern farmers, but milk production is also being affected by high temperatures. Environmental factors hold the same importance as genetic factors and the farmer's impact. West (2003) claims that the greatest challenge for farms is heat stress. Also, Trnka et al. (2011) suggest that in the period between 2030 and 2050 the global temperature is likely to rise 5°C in total. This is a large problem for cattle and therefore for sustainable milk production. Animals try to cope with environmental influences, like temperature and humidity. The goal is to minimize the impact of environmental influence by altering the exchange of temperatures between the body and the environment (Zejdová, 2012). Feeding, moving or digesting produces large amount of heat (Doležal, 2010). Milk production itself produces body heat. Cooppock et al. (1982) claim that milk production contributes to almost 53% of overall heat produced by cattle. Also, according to Purwanto et al. (1990), high-producing cows have higher heat production. According to Velecká et al. (2014), microclimate in a barn is important for good welfare and also for competitive milk production. Thermal load of animal can be affected by housing systems, social rang and other factors (Berman et al., 1985). High humidity and temperature combined together not only negatively influence the milk yield, but also its quality, reproduction and feed intake (Erbez et al., 2012). All these negative effects can be alleviated by using technologies such as fans, sprinklers and showers (Her et al., 1988). Bouček et al. (2009) suggest in their work that tolerance to heat stress also depends on the stage of lactation. According to this work, the ability to cope with high temperatures is the worst right after calving and during the first period of lactation. The aim of this study was to assess the effect of environmental cooling rate and temperature-humidity index on the milk yield of Holstein cattle.

Materials and Methods

The experiment for this study was held on the university farm in Žabčice. This experiment lasted over one month (August) during the summer. 143 cows of Holstein cattle in total were included in this experiment. These cows were the most productive in the herd (36.91 kg of milk per day). All the cows on farm are milked twice a day.

The feed ration was the same for all cows during the whole duration of the experiment. This feeding ration included the corn silage, sugar beet pulp, grinded limestone, lucern hay and other feeds.

The barn was built as a conventional cattle barn with open sides. This barn was also equipped with stable fans for cooling the animals down. The temperature itself was represented by environmental cooling rate (ECR). The ECR was calculated according to a formula by Chloupek and Suchý (2008):

$K = F / t$, where t = time of cooling and F = factor of the Hill's thermometer

The data for this formula were collected by Hill's thermometer. This thermometer was filled with 38 °C hot water. Later, it was observed how long it took to cool water from 38°C to 35°C. This is called the time of cooldown. The data about the ECR were collected on a daily basis at the same time (11:00 AM). The data about milk yield were collected directly from the milking parlour. The temperature-humidity index (THI) was calculated according to the following formula (Hahn, 1999):

$THI = 0,8tdb + ((tdb – 14.4) * RH)/100 + 46.4$, where T_{db} = air temperature and RH = relative humidity

The data about temperature and humidity were both collected by data loggers (HOBO) placed in the middle of the sections in the height of withers. Both temperature and humidity data were collected each 30 minutes. Statistica 12 was used to correlate the ECR and yield and the THI and yield.

Results and Discussion

Figure 1 shows the relationship between the ECR and the yield. This relationship is very weak (r=0.069 p=0.05). Zejdová et al. (2014) suggest in their work that the ECR has large influence on the behaviour of cattle. This statement could be supported by findings of Louda et al. (1999). In this work, it is suggested that along with the THI, the ECR affects the stable environment the most. It is apparent from the figure that with higher ECR, the yield slightly rises.

This could mean that with higher ability of the environment to cool down, the production is slightly better. During the heat periods with insufficient stable cooling, the cattle became lethargic and with lower will to feed (Pennington and van Devender 2006). All of this causes decrease in milk production.

Table 2 displays relationship between the THI and the milk yield. The THI is in the negative relation to the yield (0.139, p=0.05). This relation is stronger than between the yield and the ECR.

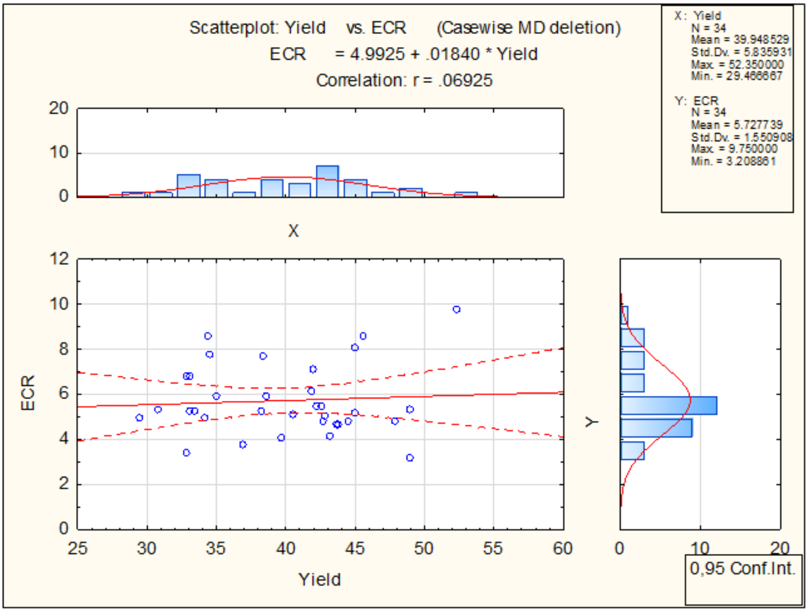

Fig. 1. Relation between the ECR and the milk yield
Однос између ECR и приноса млијека

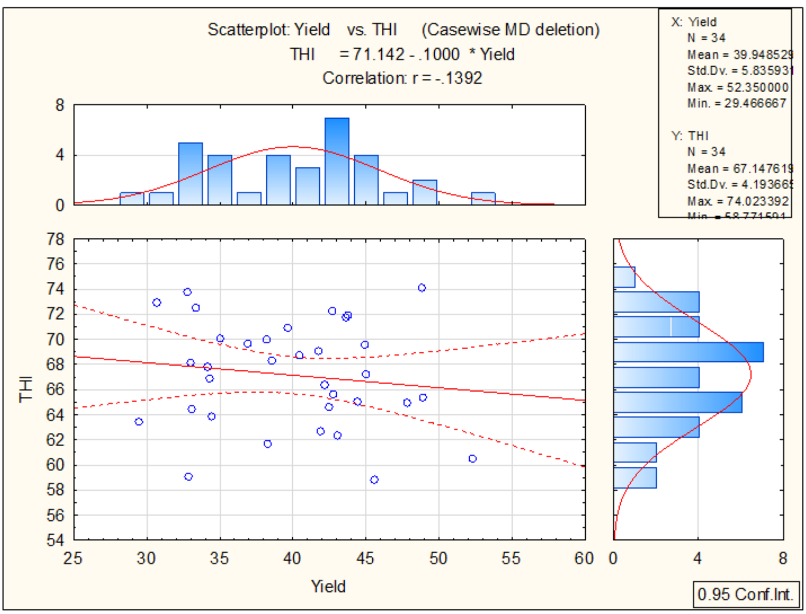

Fig. 2. Relation between the THI and the milk yield
Однос између THI и приноса млијека

According to Zejdová et al. (2014), the THI has a large impact on the behaviour of cows, but Doležal (2010) claims that with higher THI the intake of concentrated feed did not decrease.

The THI also affects cattle behaviour that is directly connected to the milk production. Although the average THI is 67, which is considered in thermoneutral zone, there are severe THI peaks reaching 75, which is considered moderate heat stress. Provolo and Riva (2009) in their work suggest that the THI positively affects the length of lying period of cows. This could mean less time and will for feeding and therefore slight decrease in milk production.

Conclusion

This paper targeted the effect of environmental cooling rate (ECR) and temperature-humidity index on the milk yield of Holstein cattle on a specific farm. Results show that there is a very weak negative relationship (r=0.069) between the ECR and the yield. When it comes to the THI, the relation to milk yield is negative and stronger (r=-0.1392) than for the ECR. This shows that the yield itself is less negatively influenced by the ECR than by the THI. It could be caused by longer light periods during the summer and therefore higher milk production.

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References

Berman, A., Folman, Y., Kaim, M., Mamen, M., Herz, Z., Wolfenson, D. and Graber, Y. (1985). Upper critical temperatures and forced ventilation effects for high-yielding dairy cows in a subtropical climate. *Journal of Dairy Science, 68*(6), 1488–1495.

Brouček, 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 Journal of Animal Science, 42*(4), 167–173

Coppock, C.E., Grant, P.A., Portzer, S.J., Charles, D.A. and Escobosa, A. (1982). Lactating dairy cow responses to dietary sodium, chloride, and bicarbonate during hot weather. *Journal of Dairy Science, 65*(4), 556 – 576.

Doležal, O. (2010). *Metody eliminace tepelného stresu-významná chovatelská rezerva* (p. 41). Praha.

Erbez, M., Bøe, K. E., Falta, D. and Chládek, G. (2012). Crowding of dairy cows in a cubicle barn during the hot summer months. *Archiv Tierzucht*., *55*(4), 325–331.

Her, E., Wolfenson, D., Flamenbaum, I., Folman, Y., Kaim, M. and Berman, A. (1988). Thermal, productive, and reproductive responses of high yielding cows exposed to short-term cooling in summer. *Journal of Dairy Science*, *71*(4), 1085-1092.

Chlpukek, J. and Suchý, P. (2008). Mikroklimatická měření ve stájích pro hospodářská zvířata. Fakulta veterinární hygieny a ekologie, p.229, VFU Brno.

Louda, F. (1999). *Chov skotu: přednášky. 1. vyd* (p. 186). Praha: Česká zemědělská univerzita v Praze.

Pennington, J.A. and Van Devender, K. (2006). *Heat Stress in Dairy Cattle*. [Online]. Available at: http://www.uaex.edu/Other_Areas/publications/PDF/FSA-3040.pdf. [Cit. 2011-07-20].

Provolo, G., and Riva, E. (2009). One year study of lying and standing behaviour of dairy cows in a frestall barn in Italy. *Journal of Agricultural Engineering*, *40*(2), 27-34

Purwanto, B. P., Abo, Y., Sakamoto, R., Furumoto, F. and Yamamoto, S. (1990). Diurnal patterns of heat production and heart rate under thermoneutral conditions in Holstein Friesian cows differing in milk production. *The Journal of Agricultural Science*, *114*(2), 139–142.

Trnka, M., Olesen, J. E., Kersebaum, K. C., Skjelvåg, A. O., Eitzinger, J., Seguin, B., and Dubrovský, M. (2011). Agroclimatic conditions in Europe under climate change. *Global Change Biology*, *17*(7), 2298-2318.

Velecká, M., Javorová, J., Falta, D., Večeřa, M., Andrýsek, J. and Chládek, G. (2014). The Effect of Temperature and Time of Day on Welfare Indices in Loose-housed Holstein Cows. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *62*(3), 565–570.

West, J.W., Mullinix, B.G. and Bernard, J.K. (2003). Effects of hot, humid weather on milk temperature, dry matter intake, and milk yield of lactating dairy cows. *Journal of Dairy Science*, *86*(1), 232–242.

Zejdová, P., Chládek, G. and Falta, D. (2014). *Vliv stájového prostředí na chování a mléčnou užitkovost dojnic*. Brno: Mendelova univerzita v Brně.

Утицај степена расхлађивања околине и индекса температуре и влажности ваздуха на принос млијека крава расе холштајн у специфичним условима узгоја

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Сажетак

Циљ овог рада је процјена утицаја степена расхлађивања околине и индекса температуре и влажности ваздуха на принос млијека крава расе холштајн у специфичним условима узгоја. Експеримент је реализован на локалној фарми у склопу универзитетског комплекса (Јужна Моравија) у љето 2017. године и трајао је нешто више од једног мјесеца. Најпродуктивнија грла су одабрана за ову студију с обзиром на претпоставку да су она више изложена топлотном стресу у односу на мање продуктивнија грла. Степен рсхлађивања околине (ECR) је измјерен Хил-овим термометром и касније прерачунат путем одговарајуће формуле. Индекс температуре и влажности је израчунат из података о температури и влажности ваздуха са инструмента постављеног у самој штали. Подаци за принос млијека су добијени директно из мљекаре. Према добијеним резултатима, ECR је у слабој позитивној корелацији (r= 0.07) са приносом млијека. Међутим, THI је био у средње јакој негативној корелацији (r= -0.14) са приносом млијека.

Key words: степен расхлађивања околине, холштајн раса, топлотни стрес, THI, принос млијека

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