Physiological indicators of beginning heat stress in grazing Holstein dairy cows

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Introduction The continuous direct exposition to solar radiation coupled with their own metabolic heat production, due to ruminal fermentation and milk synthesis, make grazing dairy cows particularly susceptible to heat stress. Changes in the biological functioning of cows that suffer from heat stress may have negative effects on reproductive performance, animal welfare and health. Vaginal temperature (VT) is very sensitive to environmental conditions and known to be a good indicator to reflect physiological and pathological processes (Ammer et al., 2016). The temperature humidity index (THI) and the comprehensive climate index (CCI) are used to assess the effect of climatic conditions on dairy cattle. The THI is calculated out of the ambient temperature (T) and the relative humidity (RH) and the CCI additionally includes the solar radiations (Rad) and the wind speed (WS) (NRC, 1971, Van Iaer et al., 2015). The objective of the present study was to identify physiological indicators of beginning of heat stress in dairy cows in a pasture-based production system in Switzerland.

Materials and Methods The study was performed on 24 primiparous and multiparous Holstein dairy cows between the 6th of June and the 6t^{h} of September 2018 at Agroscope (Posieux, Switzerland). At the beginning of the study cows produced 36.7 ± 6.7 kg of milk and were 95 ± 34 days in milk. The cows were divided into 2 homogeneous treatment groups based on milk production, body weight, coat color and days in milk. Cows were paired randomly and each pair was pastured with another pair, resulting in six paddock groups. Data were collected during six periods with increasing THI. A period consisted of 2-3 days with "beginning heat stress" (daily mean THI < 65) and the following consecutive 2-3 days with "mild heat stress" (daily mean 65 ≤ THI < 72). During "beginning heat stress", all animals grazed full-time. During "mild heat stress", three paddock groups were kept inside the barn from 1130 until 1500, while the other three paddock groups remained on pasture. For the following period the treatments for the paddock groups were switched over. Subsequently, each pair was combined with another pair to get different paddock groups for the 3th/4th and 5th/6th period. To continuously measure body temperature every 10 min, a microprocessor-controlled temperature logger (STAR-ODDI, Garðabær, Iceland) attached to a modified vaginal controlled internal drug release device (Eazy-Breed, Parsippany, NJ, USA) was inserted into the vaginal cavity of each dairy cow. Blood samples were collected once a day between 1500 and 1550 and the concentrations of plasma metabolites (glucose, BHB, NEFA) and hormones (T3, T4) were analyzed. Milk for the analysis of cortisol concentration was sampled twice a day (0430-0530 and 1600-1700). On pasture, a weather station (Onset, Bourne, MA, USA) recorded T, RH, WS and Rad every minute. In the barn, T and RH were recorded every 15 min with a logger (Testo, Mönchaltorf, Switzerland). Data was analyzed in two time windows: 0900-1130 (AM) and 1140-1300 (PM). Data are represented as mean ± SD. In the following preliminary results from univariate linear mixed regression models irrespective of treatment are shown for the 1st/2nd and the 5th/6th periods (except for cortisol that was analyzed for the 5th/6th period only).

Results and Discussion During the four periods, the THI_{AM} was 64.5 ± 4.6, the CCI_{AM} was 24.0 ± 5.3 °C, the THI_{PM} was 66.9 ± 4.3 and the CCI_{PM} was 26.4 ± 5.3 °C. CCI and THI were closely correlated ($r = 0.97$, $p < 0.001$) so that they seem to be equally suitable to estimate the effect of climate conditions on dairy cows. The VT_{AM} was 38.4 ± 0.2 °C and the VT_{PM} was 38.5 ± 0.3 °C. VT_{AM} increased by 0.02 °C per increase in THI_{AM} unit ($p < 0.001$) and VT_{PM} increased by 0.03 °C per increase in THI_{PM} unit ($p < 0.001$). The T4 concentration was 37.8 ± 11.1 nmol/l. T4 decreased by 0.1 nmol/l per increase in THI_{AM} unit ($p < 0.05$) and it decreased by 0.2 nmol/l per increase in THI_{PM} unit ($p < 0.001$). The T3 concentration was 2.0 ± 0.3 nmol/l. T3 decreased by 0.006 nmol/l per increase in THI_{AM} unit ($p < 0.01$) and it decreased by 0.008 nmol/l per increase in THI_{PM} unit ($p < 0.001$) suggesting that thyroid hormones could be important for acclimation during heat stress (Weitzel et al., 2017). Associations of THI with glucose (3.1 ± 0.2 mmol/l), BHB (0.7 ± 0.1 mmol/l) and NEFA (0.1 ± 0.1 mmol/l) could not be detected but might be attributed to the cow's variation in stage of lactation and changes in grass quality. The cortisol concentration in the milk obtained in the morning was 2.6 ± 1.4 nmol/l and 1.8 ± 1.4 nmol/l in the afternoon. Cortisol concentration in the milk harvested in the afternoon increased by 0.02 nmol/l per increase in THI_{PM} unit ($p < 0.05$) indicating that animals perceived the increase of the THI as a stressor. An association between cortisol concentration in the milk harvested in the morning and THI could not be detected.

Conclusions In the range of the measured climate conditions, we could see an increase in VT and cortisol concentration and a decrease in T4 and T3 concentration with increasing THI indicating that heat stress has an impact on metabolites and hormones. They could be potentially used as physiological indicators of beginning heat stress in grazing Holstein dairy cows.

References

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