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EFFECT OF TEMPERATURE CUMULATION ON MILK YIELD OF CZECH FLECKVIEH-SIMMENTAL CATTLE

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Abstract

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The aim of this study was to asses the effect of temperature cumulation on milk yield of Czech Fleckvieh-Simmental cattle. Experiment for this study was executed on private farm in Czech Republic with permanently open-sided barn, in which were cows stabled (49°12′36.7″N 16°23′42.1″E). Cows were stabled in free stall box system. Experiment lasted three months (May–July) of 2016. In total 114 cows were include in this study. They were divided according to yield to three groups: more than 25 kg of milk per day, 20.1–24.9 kg of milk per day and less than 20 kg of milk per day.
The data loggers placed inside the stable collected data about temperature every 30 minutes. Data about milk yield were obtained from software in milk parlour. After data were collected, the sum of effective temperatures (SET) was calculated. The SET was calculated for temperatures surpassing 21 °C. Data shows that all groups were affected by rising SET. The group with yield above 25 kg of milk per day was the most affected by the high SET ($r = -0.4931$) in contrary with the group with less than 20 kg of milk per day ($r = -0.1380$). Our result suggest, that the SET might be better marker for evaluation of the impact of heat stress than temperature itself. The results of this paper also shows, that the high-yield cows are affected by cumulation of temperature more.

Keywords: sum of effective temperatures, czech fleckvieh-simental cattle, milk yield, heat stress, summer temperatures, 21 °C, temperature cumulation

INTRODUCTION

Genetic, enviromental and seasonal factors have large influence on the yield and milk quality (Cimen *et al.*, 2010; Bayram *et al.*, 2009). Other factors, like stage of lactation and parity (Summer *et al.*, 2003) and feed (Davies and White, 1958) are also relevant factors of milk production. High temperature is one of these factors. The high temperatures are detrimental for production of commercially sold animal products (Fuquay, 1981; Morrison, 1983). According to Purwanto *et al.* (1990) the cows that have bigger yield suffer from heat stress more. This effect could be alleviated by cooling technologies like fans or showers (Her *et al.* 1988). West *et al.* (2003) claims, that hot weather has greater effect on yield in comparing to cold period which had minor influence.

The effective microclimate in barn is essential for good welfare and to achieve the competitive milk production (Velecká *et al.*, 2014). Berman *et al.* (1985) claim that the thermal load of animal could be affected by factors like housing system, location of animal and social rank. When the temperature and humidity are both high the influence on feed intake, reproduction and milk production is negative (Erbez *et al.*, 2012). According to Vokřálová *et al.* (2007) the thermoneutral zone for cattle is between −5 °C and +24 °C. Also the temperature of 21 °C should not be exceeded as described above.

European cattle tolerate lower temperatures better than higher temperatures (Novák *et al.*, 2000). According to Angrecka and Herbut (2015) only small decrease in milk production (1–2 kg) per day is present when cold stress in imminent. Cold weather and low temperature put, however, higher requirements on on quality and quantity of feed ration (Doležal and Černá, 2003).

Toleration of heat stress also depends on the phase of lactation. Bouček *et al.* (2009) in their work claim, that the ability to cope with temperature stress is worse right after calving and during the first stage of lactation.

Economic losses are at hand when heat stress is imminent. According to St-Pierre *et al.* (2003) the losses in some states of USA are $728 million anually, which is around 43 % of all national losses.

Lin *et al.* (2007) used sum of effective temperatures (SET) method for seahorse egg development. Also this metod can be used by fruit producers for calculationg rippening period of fruit. SET is a sum of temperatures, that are significant for development, rippening or other physiological processes of organisms. It can be used for various analysis. Finch *et al.* (1986) in their work suggest that if the gain of heat is larger than heat losses, heat is stored in the body. As mentioned above, a number of studies were made on fruit and insect. When it comes to cattle, very little is known about cumulation of temperature and SET effect on it. Therefore SET calculation was used to evaluate effect of cumulation of temperatures on milk yield of Czech Fleckvieh-Simmental.

MATERIALS AND METHODS

Experment for this paper took place in Genagro Říčany (49°12′36.7″N 16°23′42.1″E), Czech Republic, between May and July 2016. The group with the biggest yield in herd, that was stabled together was chosen. Therefore there was a presumption for the biggest impact of temperature cumulation. These cows were for calculations divided to three groups: G1 (25+ kg of milk per day), G2 (20.1–24.9 kg of milk per day) and G3 (20 and less kg of milk per day). Also we used mean values of whole section as total.

There were 114 cows in total. Each group had 38 cows in average. The number of lactation varied, but number of cows with same lactation was same in all groups. This number varied slightly throughout the experiment according to transfer from and to another groups. They were all fed the same feed ration: 22 kg of maize silage, 13 kg of lucerne silage, 0.7 kg of cut straw, 4 kg of sugar beet pulp, 4 kg of molasses, 3 kg of brewing dough, and 8 kg of special mix for high-yield cows mix. This mix is specially designed for the high production cows. It contains 57 % of barely and whey, 20 % of extracted rapeseed grind, 15 % of extracted soybean grind 7 % of mineral premix and 1 % of feeding urea. The barn itself is unusuall because sides are open throughout the whole year.

For data collection we used the data logger that was placed in the very middle of the section, in height of withers. These registrators collected temperature data each 30 minutes during whole experimental period. Data about milk yield were collected from milking parlor. All of these were analyzed in program STATISTICA 12 and MS Excel 2016. The sum of effective temperatures (SET) was used as a way to asses the cumulative effect of heat on yield. From data we selected temperatures above 21 C°. We chose this temperature according to various authors claim that is the limit for cattle heat stress (Bernabucci *et al.*, 2014; Igono *et al.*, 1992). The SET value was calculated daily according to following formulas:

$$K = T - 21$$

$$SET = K_1 + K_n$$

K ....Effective temperature
SET.....Sum of effective temperatures
T..........Temperature above 21 °C
K_1 ....First effective temperature of a day
K_n ....Every other effective temperature of a day

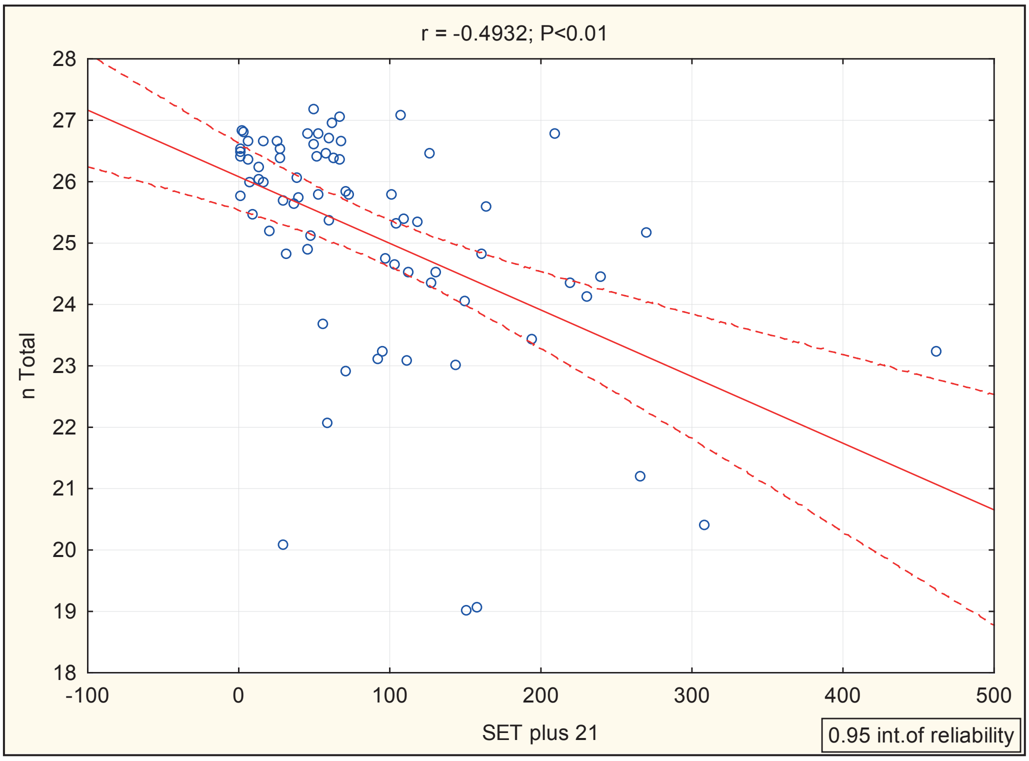
Humidity was also measured by the data loggers. Zejdová *et al.* (2014) in their work claim, that the correlation of temperature and temperature-humidity index (THI), which is usually used to evaluate heat stress, is high (0.998). Therefore in Czech Republic, there is almost no reason to use humidity in proces of evaluation of heat stress. Similar statement was made by Paldusová *et al.* (2014), who claim that THI is not not suitabe for evaluation of heat stress in Czech Republic because of mild climate withou sudden changes or extremes.

RESULTS AND DISSCUSION

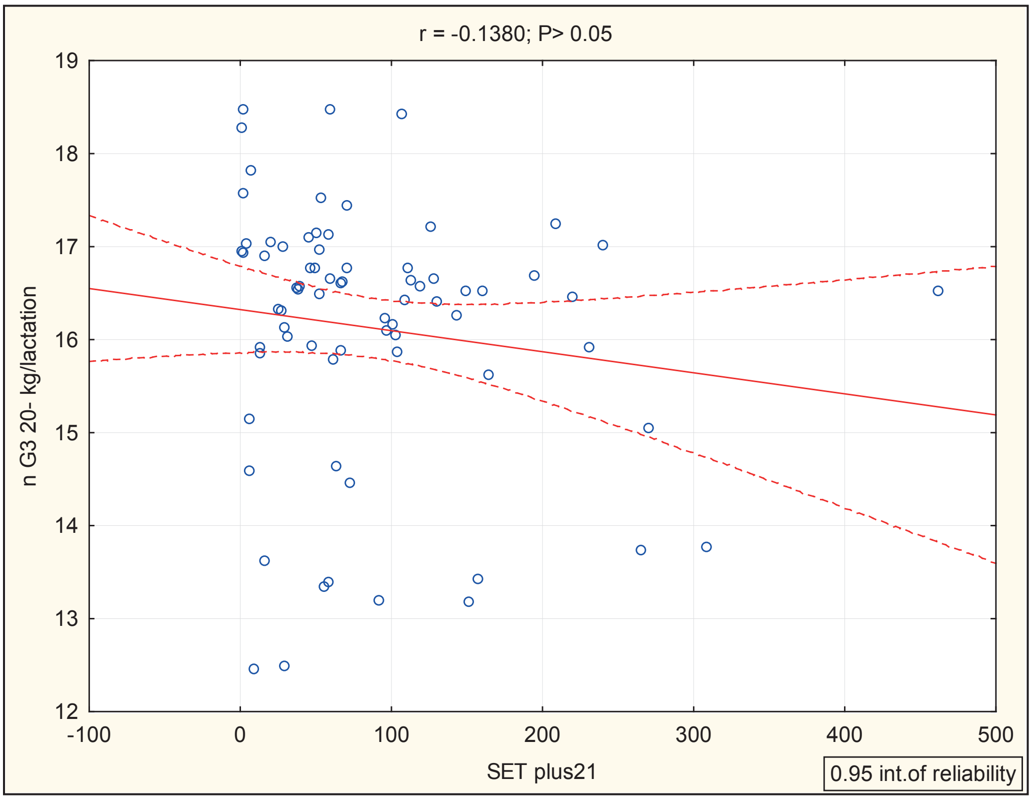
Figs. 1–4 shows correlation between each group in whole experiment. It can be observed that the group with more than 25 kg of milk per day had the strongest correlation (r = –0.4931) with the SET values. This is in contrary with the group 20 and less kg of milk per day. Correlation between SET and yield is lower here (r = –0.1380). This supports the statement of West *et al.* (2003) that claims, that temperature affects high-yield cows more, than cows with lower production. This is caused by higher heat production of high-yield cow's intensive metabolism (Purwanto *et al.*, 1990). Also work of Araki *et al.* (1984) suggest that the body temperature of cattle is very sensitive to changes of surrounding temperature which also supports results of this work.

These findings are in contrary with the work of Toušová *et al.* (2017). In their work there was claimed, that a milk yield itself was higher during the summer and hot weather. It might be caused by the overal higher production during summer, but not throughout the heat waves. It is necessary to seek for the drops in milk production and correlate them with a temperature. More research is needed on this toppic though.

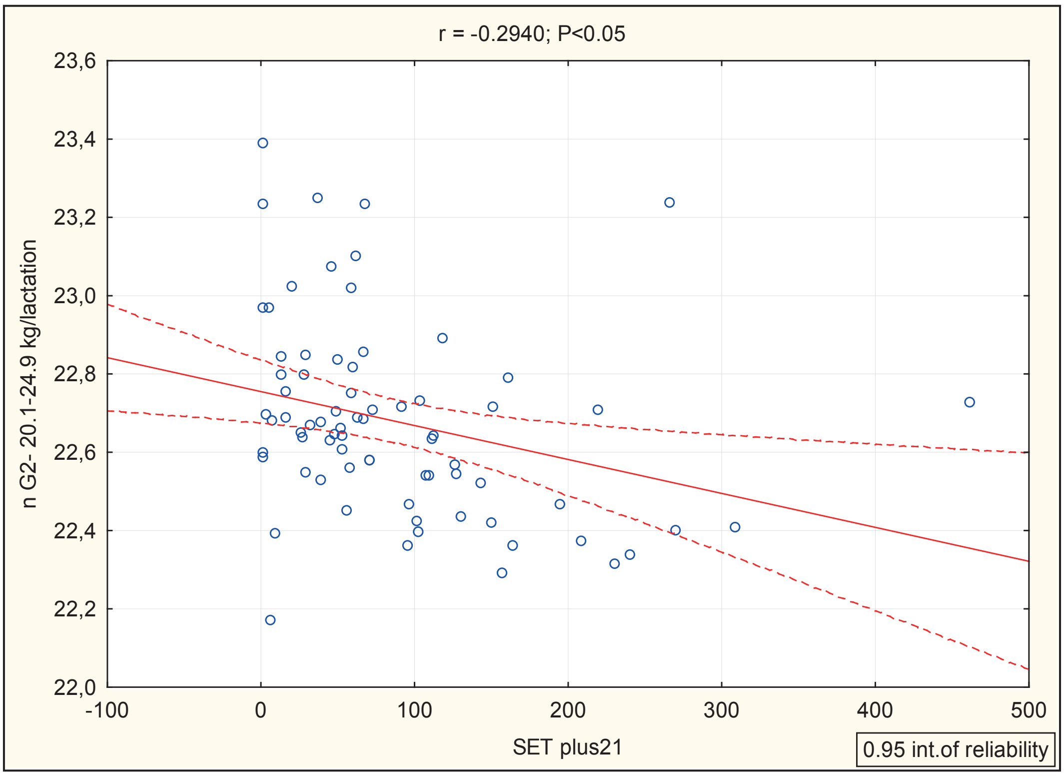
Tab. I shows the relationship between the SET and the month. As can be observed, there is a statistically difference between all three months of experiment.



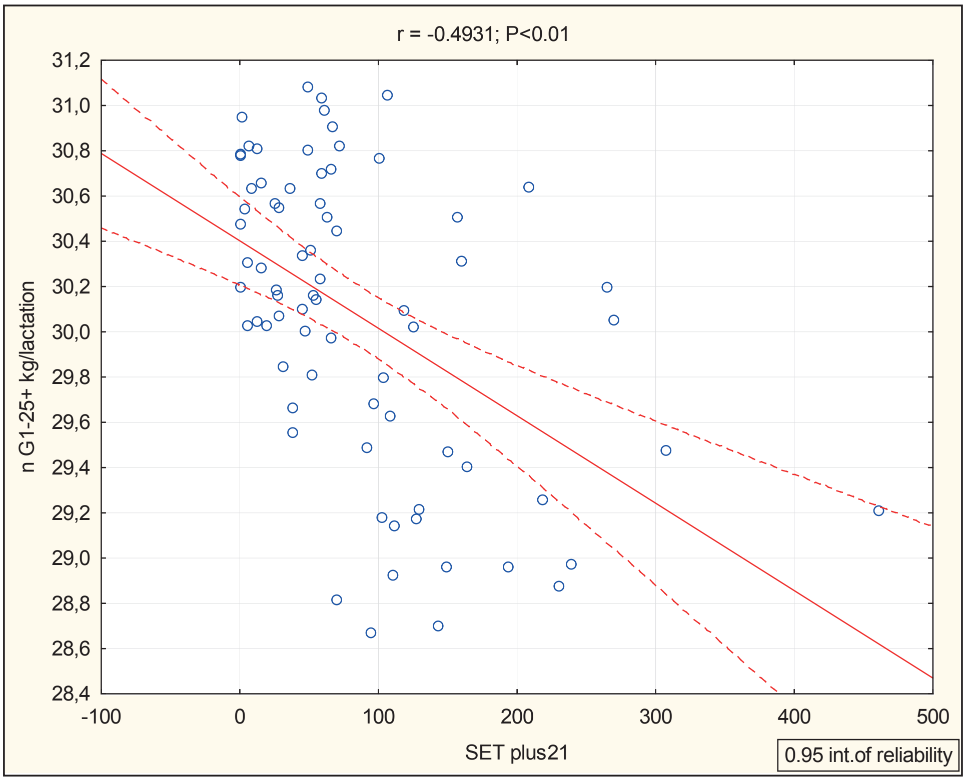
1: *Correlation between yield of all cows and SET*
Legend: n Total = yield of all cows in heard, SET plus 21 = sum of effective temperatures above 21 °C



2: *Correlation between yield of group 20 and less kg per day and SET*
Legend: n G3 20- = mean yield of cows in group 20- kg of milk per day, SET plus 21 = sum of effective temperatures above 21 °C



3: *Correlation between group with yield between 20.1–24.9 kg and SET*
Legend: n G2 20.1–24.9 = mean yield of cows in group 20.1–24.9 kg of milk per day, SET plus 21 = sum of effective temperatures above 21 °C



4: *Correlation between group with yield bigger than 25 kg per day and SET*
Legend: n G1 25+ = mean yield of cows in group 25 and more kg of milk per day, SET plus 21 = sum of effective temperatures above 21 °C

The biggest difference is between May and July. The temperatures are significantly higher even when May and June is compared. Same results are when June and July compared., although the difference here is smaller.

In Tab. III can be seen the difference between months and average yield in each group. The significant difference can be observed for all groups, with exception of the last low-yield group. The group with yield 25 and more kg per day shows the biggest decline in the yield overall whole period of experiment. This supports the findings from Figs. 1–4, that the low-yield cows are affected by temperature and SET less than the high-yield ones. This supports the statement of Kadzere *et al.* (2002), who in their work claim that the cows with higher production of milk are affected by heat stress more than that with lower yield.

I: *Relationship between SET and month*

Month	SET plus 21				
	Mean	Min	Max	Sx	Vx
V.	58.04^{A}	0.99	444.84	93.57	161.22
VI.	74.54^{AB}	3.56	308.18	79.70	106.92
VII.	133.24^{AB}	20.10	461.51	90.23	67.72

Values in the same column marked with different symbols (A to B) are different (P < 0.01)

II: *Relationship between month and yield*

Month	Group 25+ (kg/day)					Group 20.1–24.9 (kg/day)					Group 20– (kg/day)				
	Mean	Min	Max	Sx	Vx (%)	Mean	Min	Max	Sx	Vx (%)	Mean	Min	Max	Sx	Vx (%)
V.	30.70^{A}	30.00	31.08	0.28	0.92	22.85^{a,A}	22.42	23.39	0.27	1.18	16.96^{a}	14.47	18.48	1.02	3.88
VI.	30.25^{B}	29.47	30.80	0.36	1.18	22.66^{b}	22.17	23.24	0.22	0.98	15.44^{b}	12.46	17.52	1.64	10.63
VII.	29.42^{C}	28.67	30.31	0.48	1.64	22.56^{B}	22.32	23.03	0.17	0.76	16.16	13.20	17.06	0.91	5.63

Values in the same column marked with different symbols (a to c, or A to C, respectively) are different (P < 0.05 or P < 0.01, respectively).

CONCLUSION

The aim of this work was to asses the effect of SET on the yield of cows. From all results we can see moderate correlation between the SET and high production group. Therefore the SET might be better marker for evaluation of the impact of heat stress. The results of this paper also shows, that the high-yield cows are affected by cumulation of temperature more than low-yield cows.

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