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Effects of the stage and number of lactation on milk yield of dairy cows kept in open barn during high temperatures in summer months

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Abstract

Objective of this paper was evaluating the effect of high temperatures on production of milk of dairy cows in southern Moravia (Czech Republic, East Central Europe). We tested hypotheses that the milk efficiency of dairy cows kept in free-stall open barn without supplemental cooling is influenced of a month of summer period, lactation stage (LS) and lactation number (LN) of dairy cows. 193 Holstein cows were used. Three stages were stated according to the days in milk at the July 1: Stage 1-peak (0-50 d); Stage 2-mid lactation (51-120 d); Stage 3-late lactation (121-200 d). We found 63 summer (SumD) and 14 tropical days (TropD), 86 days with the temperature-humidity index (THI) above 72.0, and 26 days with the THI above 78.0, from May to September. The average monthly milk yields were statistically differed ($P<0.001$) among LS, also among LN. We found significant interactions between LS and LN (May, $P<0.05$; June, $P<0.01$; July, $P<0.001$; August and September, $P<0.01$). The average monthly milk yields of Stage 1 were gradually increased from May to July (from 33.94 ± 8.99 kg on 36.62 ± 6.62 kg), then decreased to September (30.05 ± 5.69 kg). Depression of milk was significant between July and August (36.62 ± 6.62 kg vs. 32.26 ± 5.88 kg; $P<0.01$). Milk yield in the Stage 2 was the highest in May (41.55 ± 7.93 kg) and then gradually decreased until October (27.69 ± 5.12 kg). Comparisons of months, LS and LN for whole observed period from May to October differed very highly significantly, there were recorded interactions month:LS ($P<0.001$), month : LN ($P<0.01$), and LS : LN ($P<0.001$). Dairy cows of Stage 1 were affected by the high temperatures in milk production for 305 days lactation significantly more than cows from Stage 2 (8 954.4 ± 1 526.9 kg vs. 9 614.1 ± 1 488.6 kg; $P<0.05$).

Keywords: dairy cows, milk yield, high temperatures, lactation stage, lactation number

Zusammenfassung

Einfluss des Laktationsstadiums und der Laktationsnummer auf die Milchleistung der im Offenstall während höherer Temperaturen in den Sommermonaten gehaltenen Kühe

Ausgewertet wurden der Einfluss der wärmeren Sommermonate auf die Leistungen von 193 Holstein Kühen die in Südböhmen in der Tschechischen Republik im Offenstall gehalten wurden. Berücksichtigt wurden die drei Laktationsstadien 1. (0.-50. Tag), 2. (51.-120. Tag) und 3. (nach dem 120. Laktationstag). Beobachtet wurden in den Monaten Mai bis September 63 Sommer-, 14 tropische Tage, 86 Tage mit einem Temperatur-Feuchte-Index (THI) über 72,0 und 26 Tage mit einem THI über 78,0. Signifikante Unterschiede ergaben sich sowohl bei den Laktationstadien als auch den Laktationsnummern sowie Interaktionen zwischen diesen. Die durchschnittliche tägliche Milchleistung im Stadium 1 stieg allmählich von Mai bis Juli von 33,94 ± 8,99 kg auf 36,62 ± 6,62 kg und sank bis September auf 30,05 ± 5,69 kg. Diese Senkung der Leistung von Juli bis August von 36,62 ± 6,62 kg bis 32,26 ± 5,88 kg war signifikant. Im Stadium 2 erreichten die Tiere mit 41,55 ± 7,93 kg die höchsten Leistungen und diese sanken dann allmählich bis Oktober auf 27,69 ± 5,12 kg. Die Vergleiche der Monate, Laktationsstadien und -nummern erwiesen sich ebenso wie die Interaktionen zwischen diesen Beurteilungskriterien als hochsignifikant. Die Milchleistungen der Kühe im Stadium 1 wurden gegenüber dem Stadium 2 während der 305 Laktationstage durch höhere Temperaturen signifikant stärker beeinflusst (8 954,4 ± 1 526,9 kg bzw. 9 614,1 ± 1 488,6 kg).

Schlüsselwörter: Milchkühe, Milchleistung, hohe Temperaturen, Laktationsstadium, Laktationszahl

Introduction

Dairy cattle are adaptable to a wide range of climatic conditions, but can be severely challenged by heat stress. Repeated periods with high temperatures, with little air flow or cloud cover, are periods of concern. Although effects are more severe in hot climates, dairy cattle in areas with relatively moderate climates also are exposed to periods of heat stress. High temperatures depress milk production in many areas of the Europe. Heat stress occurs when any combination of environmental conditions cause the effective temperature of the environment to be higher than the animal‹s comfort zone (WOLLNY *et al.* 1998, TARALIK 1998, TAWFIK *et al.* 2000).

Summer depression of production causes significant economic loss in the dairy industry. The basic condition of management in dairy farms consists in understanding factors that affect milk production mostly, i.e. with the exception of nutrition and dairy cow health status also the lactation number (LN) and season of calving, technological systems, and especially microclimatic conditions (ZIEGLER and WENIGER 1990, GADER *et al.* 2007). These factors should be considered not only from the viewpoint of the total milk yield but also from that of the level of milk production, especially the slope of the lactation function. Important role plays the lactation stage (LS) (MAUST *et al.* 1972, JENTSCH *et al.* 2001), cows in mid lactation were most adversely affected and cows in early lactation least. The heat stress problem is getting worse as production levels continue to rise (FUQUAY 1981). Livestock performance is affected by heat stress because an animal having difficulty in losing heat will decrease its heat production by lowering feed intake (KLEIN and WENIGER 1986a, KAISER and WENIGER 1993). This act results in lower milk production. Generally, the higher producing the cow, the greater the heat load produced from digestion and metabolism (KAISER and WENIGER 1994a).

The upper critical air temperature for lactating cows is in the range of 24 to 27 °C (FUQUAY 1981). However, 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 (RH) (YOUSEF 1987). Cows under a permanent heat stress seem to strike a new metabolic balance with reduced energy intake and milk production and increased heat dissipation (NAUHEIMER-THONEICK *et al.* 1988). Life stage, conditioning, and nutritional and health status also influence the level of vulnerability to environmental stressors (HAHN 1999). Daily milk yield was depressed during short-term heat exposure. During the recovery phase, daily milk yield exhibited a further decline (BROUCEK *et al.* 1998, OMINSKI *et al.* 2002). However, according to BURMEISTER *et al.* (1990) lactating cows that had been exposed to periodic temperature stress showed a regenerative tendency in milk yield during recovery periods. AMANI *et al.* (2007) found that the lactation number (LN) had significant influences on all studied traits in high temperature conditions. There was a large significant difference between the first and second lactation and despite the fact that the maximum milk yield was reached in the fourth lactation it was not significantly different from the mean of the third lactation.

The temperature-humidity index (THI) is commonly used as a practical indicator for the degree of stress on dairy cattle caused by weather conditions (YOUSEF 1987, HUBBARD *et al.* 1999), because the THI incorporates the effects of both ambient temperature and RH in an index. In the warning to critical range of THI of 70-72, performance of dairy cattle is inhibited and cooling becomes desirable. At THI of 72-78, milk production is seriously affected. In the dangerous category at THI of 78-82, the performance is severely affected and cooling of the animals become essential (DU PREEZ *et al.* 1990). All the adverse effects of the dangerous category are present in the emergency category at THI values of 82 and above, deaths may easily occur and cooling of the animals is absolutely essential (ARMSTRONG 1994, WEST 2003). Nienaber *et al.* (2003) cited emergenced THI value from 84. According to the review by JOHNSON (1987), milk yield starts to decline at 72 mean THI and losses in milk production are clearly related to changes in THI. Marked declines occur around 76-78 mean THI. A decrease in milk yield is 0.26 kg/day for each increase in THI. BERMAN (2005) reccommended the model heat balance which is accounted for effects of body weight, exposed body surface, milk production, hair coat, sweating, radiant heat, air velocity, humidity, and temperature.

The heat stress problem is acutely felt also in East Central European countries. The weather of these countries is characterized by moderate or high summer temperatures coupled with moderate humidity levels. Hot weather causes heat stress in dairy cows leading to declines in milk production each summer. These declines can be reduced or eliminated by using of open barns for optimum milk production.

Objective of this paper was evaluate the effect of high temperatures on production of milk of dairy cows in southern Moravia (Czech Republic, East Central Europe) in the year of 2004. We supposed that milk production of dairy cows kept in barn with good design is influenced of a month, LS and LN of dairy cows.

Material and methods

193 Holstein dairy cows were used. The month of calving was the main criterion to select dairy cows. We evaluated data from test milk records, taken at 30-d intervals of the period from December 2002 to May 2004 (all number of lactations). Three stages were stated

according to the days in milk at the beginning of the hottest temperatures – 1st July: Stage 1 – peak (0-50 d – cows calved in May and June, the lactation started during the first milk performance control in May or June); Stage 2 – mid lactation (51-120 d – cows calved during March and April); Stage 3 – late lactation (121-200 d – cows calved in December to February). We compared total milk yields in 305-d lactation and total lactation, yield in 305-d lactation corrected in 4% content of fat (FCM) and index of persistency of dairy cows. Individual milk yields were recorded by Tru-tests.

Dairy cows were kept in reconstructed barn with three-row free-stall housing (rubber mattress flooring) and natural roof ventilation. Southern side of barn was opened. Cows had no supplemental cooling from fans or misters. During the observed period they were in the same housing conditions. Cows had access to unroofed, unbedded yards (10 m^2/cow).

Milking herringbone parlor was installed in a separate part of the stable. Cows were milked four times daily in the first 100 days of lactation. Milking was carried out twice daily from 101 day of lactation.

The total mixed ration was supplied to the troughs by a feeding wagon two a day during milking. Feeding was allowed throughout the 24 h period, except during milking. The energy content in feed ration for the cows in the peak phase of lactation was 7.05 MJ NEL/kg of dry matter (DM), in the second phase 6.43 MJ NEL/kg DM, and in the third phase 5.48 MJ NEL/kg DM, respectively. The composition of the total mixed ration was constant in the year and include corn silage, beet pulp, alfalfa haylage, hay, corn grain, wheat, concentrate mixture, water and mineral and energetic components. Feed ration included the factors for maintenance, growth, reproduction and lactation.

The meteorological data were recorded continuously by electronic probes inside of barn (put at animal height) and outside which connected to a data logger. We determinated the number of summer days (SumD) (maximum temperature above 25.0 °C) and tropical days (TropD) according to maximum temperature above 30.0 °C from 24 h records in the inside of barn. THI was calculated as proposed by NIENABER *et al.* (1999) by combining maximum temperature (T_{max}, °C) and average RH (%) per day inside barn with the following expression:

$$THI = 0.8 \cdot T_{max} + \frac{\%\ average\ RH}{100} \cdot (T_{max} - 14.4) + 46.4 \quad (1)$$

The data were analyzed with a statistical package STATISTIX 8 (2004). The normal distribution of data was evaluated by Wilk-Shapiro/Rankin Plot procedure. All data confirmed to a normal distribution. Among-group comparisons of the milk production and milk composition in each factor were analyzed using a General linear model ANOVA (General AOV/AOCV). The dependent variables were milk yield, FCM, length of lactation and index of persistency, and the independed variables were the factors month, stage and parity.

The homogeneity of variance of the observed variables in groups, whose average values are being compared, was calculated by preliminary variance tests, which determined whether the variability's are equal. Bartlett's test for equality of variance tests was applied with an unequal size of samples. The ratio of the largest within-group variance over the smallest was also tested (Pearson and Hartley test). Significant differences among means were tested by Bonferroni's test. We chose Bonferroni's method from Multiple Comparison Procedures since the number of dairy cows in groups was unequal. This test is generally more conservative than other from Statistix packet.

Results and discussion

The summer at 2003 year was in the East Central Europe extremely hot and high temperatures were manifested already from May. In the July, there were 17 SumD and 7 TropD, in the August 23 SumD and 6 TropD (Table 1). The high temperatures were recorded also in September (11 SumD). In the present study were found 63 SumD and 14 TropD to the end of September in total.

Table 1
Meteorological parameters during observed period with high temperatures
Meteorologische Parameter während des Beobachtungszeitraumes

Week	T-inside		T-outside	THI	Days with		SumD/TropD	Month
	average	max	average	average	THI>72	THI>78		
1	16.9	20.4	16.1	66.7	2	0	0	May
2	14.6	19.2	12.6	65.0	1	0	0	
3	16.6	21.3	14.4	67.9	2	0	1/0	
4	14.5	19.3	11.9	64.8	0	0	0	
5	18.6	23.4	16.6	70.9	4	0	2/0	June
6	20.8	25.7	18.9	75.0	5	2	5/1	
7	19.7	24.3	17.8	72.2	4	0	3/0	
8	19.2	23.2	17.3	71.3	4	0	1/0	
9	19.1	23.9	17.3	72.2	5	0	1/0	July
10	20.5	25.0	19.3	73.7	6	0	4/0	
11	18.3	22.3	15.9	69.9	3	0	1/0	
12	25.6	31.2	24.8	82.9	7	7	7/6	
13	21.8	26.1	19.8	75.0	5	2	4/1	
14	23.1	29.6	21.5	79.7	7	6	7/2	August
15	23.8	29.1	22.6	78.6	7	4	7/2	
16	22.9	28.7	22.2	78.2	7	4	6/2	
17	20.0	24.5	18.1	72.6	6	0	3/0	
18	19.7	24.6	18.8	72.4	5	0	5/0	September
19	19.8	25.4	18.0	73.1	5	1	4/0	
20	17.8	22.4	16.4	69.4	1	0	2/0	
21	14.6	18.6	13.0	63.9	0	0	0	
22	14.8	19.2	12.3	65.3	0	0	0	
23	16.2	20.9	14.5	67.6	0	0	0	October
24	10.0	13.3	7.6	56.4	0	0	0	
25	11.3	14.5	9.1	58.1	0	0	0	
26	15.3	17.7	13.1	63.2	0	0	0	
Average/ total	18.3	22.8	16.5	70.2	86	26	63/14	

T temperature in °C, THI temperature-humidity index, SumD number of summer days (maximum T above 25 °C), TropD number of tropical days (maximum T above 30.0 °C)

The values of THI for months May to October are mentioned also in the Table 1. Eighty-six days with the value above 72.0, which is critical stress category, were found. At 26 days were recorded values higher then 78.0, which is dangerous stress category.

The average monthly milk yields were statistically differed ($P<0.001$) among lactation stages from May to October, also among lactation orders in May, June and July, August (Table 2). We found significant interactions between LS and LN (May, $P<0.05$; June, $P<0.01$; July, $P<0.001$; August and September, $P<0.01$).

Table 2
The evaluating of average milk yield (kg milk) during hot period
Durchschnittliche tägliche Milchleistung (kg) während der wärmeren Periode

Stage	N	Mean	SD	SE	Significance (*P*-values) LS	LN	Interaction
May							
1	66	33.94	8.99	1.11	***	***	*
2	61	41.55	7.93	1.01			
3	66	32.02	6.84	0.84	S2:S1***	LN1:LN2***	
Total	193	35.69	8.91	0.64	S2:S3*** S1:S3***	LN1:LN3*** LN1:LN4*	
June							
1	66	35.95	6.40	0.79	***	***	**
2	61	38.20	6.55	0.84			
3	66	29.58	6.07	0.75	S2,S1:S3***	LN3,LN2:LN1***	
Total	193	34.48	7.29	0.52			
July							
1	66	36.62	6.62	0.81	***	**	***
2	61	34.56	5.97	0.76			
3	66	27.09	5.67	0.69	S1,S2:S3***	LN3,LN2:LN1**	
Total	193	32.71	7.35	0.53			
August							
1	66	32.26	5.88	0.72	***	ns	**
2	61	33.25	6.33	0.81			
3	66	25.41	6.29	0.77	S2,S1:S3***		
Total	193	30.23	7.07	0.51			
September							
1	66	30.05	5.69	0.70	***	ns	**
2	61	28.77	5.25	0.67			
3	66	23.22	7.01	0.86	S1,S2:S3***		
Total	193	27.31	6.72	0.48			
October							
1	66	30.24	6.05	0.74	***	ns	ns
2	61	27.69	5.12	0.65			
3	66	16.50	8.94	1.10	S1,S2:S3***		
Total	193	24.74	9.17	0.66			

N number of animals, SD standard deviation, SE standard error of the mean, LS stage of lactation, LN parity *$P<0.05$, **$P<0.01$, ***$P<0.001$, ns not significant, S1 to 50th day of lactation, S2 from 51 to 120 days of lactation, S3 from 121 to 200 days of lactation

The average monthly milk yields of Stage 1 (peak) were gradually increased from May to July (from 33.94 ± 8.99 kg on 36.62 ± 6.62 kg). Then monthly milk yields started decreasing through August (32.26 ± 5.88 kg) to September (30.05 ± 5.69 kg). Differences between months of ascending period (May, June and July) and descending period (August, September and October) were significant (Table 3).

Table 3
Differences among months according to lactation stage and lactation number
Differenz zwischen den Monaten in Bezug auf Laktationsstufe und -nummer

Index	N	Mean	SD	SE	Significance (*P*-values)
LS					
1	396	33.18	7.13	0.36	M:S,O*; Ju:S,O***; Ju:A*; Jl:S,O***; Jl:A**
2	366	34.00	7.91	0.41	M:Jl,A,S,O***; Ju:A,S,O***; Jl:S,O***; A:S**; A:O***
3	396	25.64	8.45	0.42	M:Jl,A,S,O***; Ju:S,O***; Ju:A**; Jl:O***; A:O***; S:O***
LN					
1	426	29.74	6.00	0.29	M:S,O***; M:A*; Ju:S,O***; Jl:S,O***; A:O**
2	300	32.44	9.17	0.53	M:S,O***; M:A**; Ju:S,O***; Jl:S,O***; A:O**
3	234	30.52	10.31	0.67	M:S,O***; M:A*; Ju:S,O***; Jl:S,O***; A:O***
4	102	31.69	9.96	0.98	M:S,O***; M:A*; Ju:S*; Ju:O***
5	96	30.81	10.78	1.10	M:O**; Ju:O*; Jl:O*

N number of animals, SD standard deviation, SE standard error of the mean, LS stage of lactation, LN parity *P<0.05, **P<0.01, ***P<0.001, S1 to 50th day of lactation, S2 from 51 to 120 days of lactation, S3 from 121 to 200 days of lactation, M May, Ju June, Jl July, A August, S September, O October

The difference between July and August, the two hottest months, is important for an assessment of the effects of high temperatures on milk yield. Depression of milk was expressive and significant in this Stage 1 (July 36.62 ± 6.62 kg vs. August 32.26 ± 5.88 kg; P<0.01).

Milk yield in Stage 2 was the highest in May, that is, as an immediate response to exposure to high temperatures (41.55 ± 7.93 kg), and then it was steadily decreasing until October (27.69 ± 5.12 kg). Differences between May and August and September and October were very significant (Table 3). However, in the present study were only a small difference between the months of July and August (34.56 ± 5.97 kg vs. 33.25 ± 6.33 kg).

Milk yield in Stage 3 decreased regularly. Even though the individual months differed statistically (Table 3), presume that this was caused by the high temperatures but by progressing lactation.

The most affected by the high temperatures were cows placed in LN of 4. The greatest drop of absolute difference in the losses in the period from May to October was recorded in older cows from the 3rd to 5th lactations (15.47 kg; 15.99 kg and 14.7 kg). The greatest differences between May and August were observed in LN 4 and 5 (4.16 kg and 4.5 kg).

Table 4 shows the evaluation of the entire observed period from May to October. The differences between individual months, LS and LN were significantly very different, and month:LS (P<0.001), month:LN (P<0.01), and LS:LN (P<0.001) interactions were recorded.

Table 5 shows that milk production of dairy cows that were in the peak stage (Stage 1) in July and August (0- 50 days in milk), were affected by the high temperatures for 305 days of lactation significantly more than cows in the mid lactation (Stage 2) (51-120 days in milk) stage (8954.4 ± 1526.9 kg vs. 9614.1 ± 1488.6 kg; P<0.05). Very highly significant difference was found among LN in the index of persistency (P<0.001).

It is well known that cows reduce production during summer months with either acute or chronic exposure to heat stress. An ambient indicator of heat stress (i.e., temperature-humidity index) is traditionally used for prediction of milk yield during summer. JOHNSON (1987) showed that milk production will be reduced whenever THI exceeds a value of 72. Though many studies have examined the effect of heat stress on same day milk production, other studies suggest that the more significant impact might occur a few days after dairy cows are exposed to extreme heat stress (WEST *et al.* 2003, BROUCEK *et al.* 1998).

Table 4
Evaluation of whole observed period (kg milk)
Durchschnittliche tägliche Milchleistung während der gesamten Beobachtungsperiode

LN	N	Mean	SD	SE	Significance (*P*-values)			
					Month	LS	LN	Interaction
Month								
May	193	35.69	8.91	0.64	***	***	***	Mo : LS
June	193	34.48	7.29	0.52				***
July	193	32.71	7.35	0.53				
August	193	30.23	7.07	0.51				
September	193	27.31	6.73	0.48	Mo : Jl,A,S,O**			
October	193	24.74	9.17	0.66				
Total	1 158	30.86	8.71	0.25				
LS								
1	396	33.18	7.13	0.36		S2, S1 : S3***		Mo : LN
2	366	34.00	7.91	0.41				***
3	396	25.64	8.45	0.42				
Total	1 158	30.86	8.71	0.25				
LN								
1	426	29.74	6.00	0.29			LN2,LN3 : LN1***	LS : LN
2	300	32.44	9.17	0.53				14.73***
3	234	30.52	10.31	0.67				0.0000
4	102	31.69	9.96	0.98				
5	96	30.81	10.78	1.10				
Total	1 158	30.86	8.71	0.25				

N number of animals, SD standard deviation, SE standard error of the mean, LS stage of lactation, LN parity *$P<0.05$, **$P<0.01$, ***$P<0.001$, S1 to 50th day of lactation, S2 from 51 to 120 days of lactation, S3 from 121 to 200 days of lactation, M May, Ju June, Jl July, A August, S September, O October

At the present work were evaluated thermal periods from May to October, however, markedly aggravated condition were during July and August. Temperature during the hottest hours of the day could probably exceed the heat dissipating capacity of evaporative heat loss by both panting and sweating in observed cows. In this condition, the metabolic activity was affected to a slight extent by heat stress, and milk yield could decrease.

Generally, high ambient temperatures depressively affect milk production (Johnson 1986; BALTAY, 2002; Soch, 2005). However, the effects of hot environment on milk production vary with the LS. Early lactating cows can be more sensitive to the effect of heat than late lactating cows. The process associated with maintenance, digestion and metabolism. Individual variation in lactating yield and shape of the lactation curve under periodic heat stress indicates the possibility of discussing productive adaptation in high performance cattle more deeply from a genetic perspective (BURMEISTER *et al.* 1990).

There are adversed opinions on this LS effect. Milk production could be more influenced in early-lactation cows for their negative energy balance, or strongly supported by tissue stores mobilisation (GADER *et al.* 2007). Cows in the early stage of lactation extensively utilize body reserves and are less dependent on consumed feed energy. They are on the higher level of production, despite of consuming the least feed (SOCH *et al.* 2000).

Table 5
The evaluating of lactation (kg milk)
Auswertung der Laktationsleistung (kg Milch)

Stage	N	Mean	SD	SE	Significance (*P*-values) LS	LN	Interaction
Milk for 305 days							
1	66	8 985.4	1 526.9	187.94	*	ns	ns
2	61	9 614.1	1 488.6	190.60			
3	66	9 254.3	1 570.6	193.32	S2 : S1,S3*		
Total	193	9 276.1	1 543.5	111.10			
FCM for 305 days							
1	66	8 260.4	1 305.7	160.72	ns	ns	ns
2	61	8 696.8	1 350.4	172.89			
3	66	8 491.6	1 460.4	179.77			
Total	193	8 477.0	1 378.0	99.23			
Milk for whole lactation							
1	66	10 088	2 265.4	278.85	ns	ns	ns
2	61	10 491	1 994.4	255.36			
3	66	10 186	2 374.0	292.22			
Total	193	10 249	2 217.5	159.62			
Length of whole lactation							
1	66	359.56	67.28	8.28	ns	ns	ns
2	61	350.84	52.71	6.75			
3	66	351.85	63.61	7.83			
Total	193	354.17	61.53	4.42			
Index of persistency (P21)							
1	66	87.30	11.15	1.37	ns	***	ns
2	61	85.08	10.97	1.40			
3	66	87.17	13.52	1.66		LN1 : LN3,LN2,LN5,LN4***	
Total	193	86.55	11.94	0.86			

N number of animals, SD standard deviation, SE standard error of the mean, LS stage of lactation, LN parity
*$P<0.05$, **$P<0.01$, ***$P<0.001$, ns not significant

JOHNSON (1987) wrote that the average daily losses in milk production for early stage cows were 5.5 kg/day/cow, mid stage 2.6 kg/day/cow, and late stage 2.9 kg/day/cow for the first 55-day period during the summer. Heat stress in the fresh cow may impair health, decrease milk yield, and lengthen time to peak milk production and peak feed intake. However, the early cows tended to recover more during the last 55 days of the summer.

At the present work, the average monthly milk yields of peak stage (Stage 1) were gradually increased from May to July and then decreased to September. Distinc limit for production of milk was midst July and August and milk loss between those months was expressive. Milk yield in the mid lactation stage (Stage 2) was the highest in May and then was production gradually decreasing until October. This might indicate that cows from Stage 1 were afflicted by the hyperthermal stress the most. However, this reduction of the amount of milk yield in the present study distribution of the year can change in relation to many other factors, in particular to the milk yield level and to the reproduction phase.

Only after in the present work evaluated the 305-day period of lactation did receive the final answer. Dairy cows of Stage 1 were affected by the high temperatures in milk production for 305 days lactation significantly more than cows from mid lactation (Stage 2) (8 954.4 ± 1 526.9 kg vs. 9 614.1 ± 1 488.6 kg; $P<0.05$). The highest milk yield in lactation was found in cows, which were at the beginning of July on their 51 to 120 days in milk. That means that the high temperatures markedly limited efficiency of cows from Stage 1.

The higher producing cows of Stage 2 were probably less sensitive to the effects of high ambient temperatures. This contradicts the findings of MAUST *et al.* (1972) that mid-lactation cows were most adversely influenced by heat stress, whereas those in late lactation were affected fairly and those in early lactation the least. These authors also remind that cows in mid-lactation were most affected, but they seem to recover from one or more days of thermal stress better than cows in late lactation (MAUST *et al.* 1972). The generally valid statements on adaptability are difficult to make because of considerable individual differences in reaction patterns between animals. However, the broad spectrum of variation in reaction to heat stress under which a sufficient number of cows showed high lactation performance, allowed the selection of suitable breeding animals for regions with high environmental temperatures (KLEIN and WENIGER 1986b). Also, the preliminary heat treatment influences the reactions of the cows only during the initial stage of the alternating heat stress. The change to the constant heat stress results in a temporary relief (GROSSMANN *et al.* 1984, KAISER and WENIGER 1994b).

In the present study were found similarly the lowest milk production in whole lactation in cows of Stage 1 spending summer months in their peak production (about 50 days), however the differences were no significant (10 088 kg; 10 491 kg; 10 186 kg).

The effects of heat stress may be more pronounced in older cows than first-lactation heifers. At the present work the most affected by the high temperatures were cows of higher parities. THOMPSON *et al.* (1999) reported a significant reduction in 305-day milk production of second-lactation or older cows that was not seen in first-lactation heifers. It is a common field observation that heifers don’t suffer heat stress to the extents that mature cows do. Older cows were affected more severely because they had higher feed consumption, therefore digest more, produced more milk, and had more fatty insulation preventing heat loss, as compared to primiparous cows. ZÄHNER *et al.* (2004) indicated that the prevalent climatic conditions on the farms during the day induced stronger thermoregulatory responses in the cows than the conditions that prevailed during the night. However, within the measured range of climatic conditions, the cows were hardly exposed to severe cold or heat stress and thus able to cope with these conditions.

In conclusion, milk production of cows is influenced by environmental factors, especially of high temperatures during summer. Heat stress is caused primarily by high air temperature, but can be intensified by high humidity, thermal radiation and low air movement. Improving performance of animals under warm conditions involves breeding and management and modifying the environment. Hot weather conditions reduce dry matter intake and level of decreasing of milk production is also affected by stage of lactation.

Dairy cows of early stage were affected by the high temperatures in milk production for 305 days lactation significantly more than cows from mid lactating stage. We can concluded that heat stress can cause significant production and economic losses on commercial dairy farms. Therefore, appropriate housing facilities and equipment to protect dairy cows from climatic extremes have significant importance for maintaining of production.

For protecting dairy cows in East Central European countries against heat stress, several practical minimum precautions have been proposed. However, further research on heat stress on dairy cattle is essential if the dairy industry is determined to achieve more cost-effective milk production, improved herd and udder health. It will probably be necessary to study more closely the methods of the air-cooling also in open barns.

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