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THE EFFECT OF AMBIENT TEMPERATURE ON CONCEPTION AND MILK PERFORMANCE IN BREEDING HOLSTEIN COWS

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Abstract

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The aim of this study was to identify the effect of ambient temperature and season of the year on conception difficulties in Holstein cattle. The experiment was conducted on the School farm in Žabčice. Data were collected from July 2016 to January 2017. Experimental population counted 263 breeding Holstein cows, which were inseminated during the observation period. Results of this study confirmed the effect of temperature and season on conception rates in dairy cows. In winter season, successful conception was recorded in 56.36% of cows in average ambient temperature 1.48 °C, in summer season the conception rate was only 40.43% in average daily temperature 18.96 °C. A more detailed analysis revealed the highest conception rates in the dairy cows in January (88.24%) and February (91.67%). On the contrary, the worst results were recorded in September (22.73%) and October (28.57%). Evaluation of conception rate according to ambient temperature intervals showed best results for the temperatures below 5 °C. A part of the study was also evaluation of an association between daily milk yield and conception rate. This hypothesis cannot be conclusively confirmed, because milk yield was mostly similar in both groups (pregnant and non-pregnant) on the days of insemination.
The effect of lactation order and mean daily milk yield on the conception rate in cows was not confirmed.

Keywords: Holstein cattle, reproduction, conception rate, effect of temperature.

INTRODUCTION

Reproduction and fertility play a very important role in economy of cattle breeding (Bulman and Lamming, 1978). Fertility is an elementary biological and productive quality, which influences meat and milk production in cattle (Ježková *et al.*, 2004; Louda *et al.*, 2008) and it is considered to be determining for milk and meat production (Ježková *et al.*, 2004). For farm animal breeding it means ability to produce morphologically and physiologically healthy offspring. Indicators of good reproduction in a herd of cattle are obtaining one calf from one cow per year (Burdych *et al.*, 2004) and maintaining reproductive ability to the age of 8–12 years (Kudláč and Elečko, 1987). It is important to monitor and regularly evaluate reproductive parameters in cows. These parameters can not only reveal existing problems in the herd but they can be also first signals that the animals are not able to cope with the given life conditions anymore (Bouška *et al.*, 2006). Important factor, which need to be taken into account for evaluation of reproductive parameters, are the level of milk yield and breeding management (Louda *et al.*, 2008).

Reproduction is characterized by a low heritability ($h^2 = 0.05 – 0.2$). It means that fertility is largely influenced by external factors such as climate, housing, nutrition, environment, quality of nursing, breeding management, etc. (Louda *et al.* 2008; Stupka *et al.* 2013). Climatic conditions influencing reproduction and fertility include: light and the duration of daylight, temperature, air pressure, season of the year and other microclimatic conditions. Climatic conditions are a very important factor for conception of breeding cows. Koukal (2001) states that a comfortable temperature for high performance dairy cows is below 20 °C. High temperatures have a negative effect on conception (Lucy, 2002). The same conclusions were published by De Rensis and Scaramuzzi, (2003), who state that higher temperatures can not only affect the reproductive cycle but they can also cause higher embryonic mortality. Heat stress affects the ability of breeding cows to conceive, but has also a negative effect on embryo (Lucy, 2002). In heat stress, both physiological and biochemical processes maintaining constant body temperature are changed. A cooling system can have a positive effect on reproduction in cattle. Cooled dairy cows can reach fertility levels corresponding to those achieved in winter seasons. High temperatures lead to decreased physical activity of animals and the estrus manifestations are less evident (De Rensis and Scaramuzzi, 2003), feed consumption is reduced, time of rumination is shortened and water consumption increases. The cows often lie down out of their boxes in order to cool down.

Heat stress before insemination is associated with lower conception (Al-Katanani *et al.*, 1999). It also influences intrauterine environment, blood circulation in uterus decreases and body temperature increases (Roman-Ponce *et al.*, 1978). These changes are tied to frequent embryonic losses and failed inseminations (Rivera and Hansen., 2001).

Also season of the year affects conception in cows. Results of inseminations vary from month to month (De Kruif, 1978). The heat stress is the main factor that contributes to low conception rates in dairy cows inseminated in the summer months (Al-Katanani *et al.*, 1999). The decrease of conception in summer seasons can go down to 20 – 30% when compared to winter seasons (De Rensis *et al.*, 2002). Low fertility is generally associated with warm months of the year, which are from June to September (De Rensis and Scaramuzzi, 2003).

MATERIALS AND METHODS

The experiment was performed on a farm in South-Moravian region (the School farm Žabčice). Breeding cows inseminated from July 2016 to January 2017 were included in the experiment. The experimental group consisted of 263 breeding cows of the Holstein breed. The cows were selected for insemination on the basis of visual detection of estrus and confirmation by ultrasonographic examination of ovaries. The rectal method was applied for insemination and it was performed by the same technician. Pregnancy of cows was controlled ultrasonographically 30 days after insemination. The breeding cows were stabled in free housing with boxes.

Temperature data were obtained from the weather station in Žabčice. The data were processed by the statistical software STATISTICA 12.0 with the use of ANOVA.

$$y_{jkl} = \mu + S_i + T_j + M_k + e_{ijkl}$$

In which

μ .... arithmetic mean,

S_i....... season of the year (summer, winter)

T_j ...... ambient temperature (–10 to 5 °C; 5.1 to 20 °C; 20.1 to 27 °C)

M_k .... month (June, July, August, September, October, November, December, January, February)

e_{ijkl} ..... residual error

RESULTS AND DISCUSSION

Tab. I displays number and order of individual inseminations. The first inseminations after calving were performed in 139 cows during the observation period, with conception rate of 48.20%, which is a relatively good value for the Holstein breed. The average interval between previous calving and the insemination was 81 days. The cows that did not conceive (n = 72) were inseminated again after 56 days, which indicates that the control of inseminated cows is not on a good level on the farm, eventual estrus after insemination is not detected and the workers wait for the ultrasonographical examination. The conception rate after the 2nd insemination was slightly higher (51.39%) than after the first insemination. Favourable values of conception rate were evident after the 3rd and higher inseminations (3rd insemination = 62.86%, 4th insemination = 76.92%, 5th insemination = 100%). A positive fact is that all the animals became pregnant eventually, however from the economical point of view there should be an effort to ensure conception of the highest possible share of animals after the first, at the latest after the second insemination. Prolongation of the service period to 130 days also leads to prolongation of calving interval and although lactation is prolonged, the daily milk yield in the latest months of milking may not reach a level sufficient to cover the daily costs for feeding or for 1 litter of milk. Burdych *et al.* (2004) consider the service period to be one of the most important indicators of reproduction level. Louda *et al.* (2008) advise farms with average productivity to maintain the duration of the service period on the level of 80 – 90 days. In high performance dairy cows, prolongation of the service period to 110 – 125 days is tolerable. For the 5th insemination, the average duration of the service period is 266 days. Such value is absolutely unsatisfactory and unprofitable for the farm.

Tab. II displays the effect of season of the year and conception rate in individual months. It is evident that the cows conceived better in the winter season (58.64%). On the contrary, in the summer season the conception rate was only 40.43%. De Rensis *et al.* (2002) confirmed that conception in cows is worse in summer season than in winter season. In their

I: *Effect of insemination order on the length of service period*

Order of insemination	Number of dairy cows (n)	Proportion of pregnant cows (%)	Proportion of non-pregnant cows (%)	Service period (days)
1st	139	48.20	51.80	81.01
2nd	72	51.39	48.61	136.64
3rd	35	62.86	37.14	176.34
4th	13	76.92	23.08	198.77
5th	3	100.00	0.00	266.00

II: *Effect of season and month on the service period and conception in cows*

Period	Number of dairy cows (n)	Number of inseminations (n)	Average temperature on days of insemination (°C)	Proportion of pregnant cows (%)	Proportion of non-pregnant cows (%)
Summer	64	94	18.96 ± 3.31	40.43^{b}	59.57^{b}
Winter	75	162	1.48 ± 5.35	58.64^{a}	41.36^{a}
Total	139	256			
June	16	16	20.30 ± 3.55	62.50^{A}	37.5^{B}
July	25	27	14.80 ± 3.31	40.74^{Ba}	59.26^{A}
August	13	29	19.46 ± 1.90	55.17^{AB}	44.83^{B}
September	10	22	16.94 ± 3.61	22.73^{Bb}	77.27^{AC}
October	15	28	7.73 ± 3.55	28.57^{B}	71.43^{ACd}
November	12	32	3.76 ± 3.09	31.25^{B}	68.75^{A}
December	23	44	0.15 ± 3.36	56.82^{AB}	43.18^{B}
January	13	34	-5.41 ± 2.99	88.24^{Cc}	11.76^{D}
February	12	24	1.42 ± 3.44	91.67^{C}	8.33^{D}
Total	139	256			

Statistical significance within rows and columns; a, b, c, d – P ≤ 0.05; A, B, C, D – P ≤ 0.01.

study, they documented that gravidity confirmed in 90 days reached 33 % in summer season against 46 % in winter season. Results of the present study were more favourable in the overall conception rate than the results of De Remsis *et al.* (2002). Lucy (2002) states that heat stress causes increase of body temperature in animals. Increased body temperature influences functions of ovaries, quality of embryos and overall embryo development. An organism is able to regulate essential physiological functions with minimum energy consumption only in the zone of thermal neutrality, which is individual for each cow (Dolejš *et al.*, 2000). These changes of temperature can negatively affect estrus in cows. The estrus manifestations can be insufficiently pronounced with shorter duration. Therefore the determination of the right time for insemination can be more difficult.

After division of the observation period into individual months (June 2016 – February 2017) we can monitor the effect of average temperature at the time of insemination on conception of the experimental breeding cows. Tab. II shows that the best conception rates were recorded in February (91.67 %) with average temperature 1.42 ± 3.44 °C. The second highest conception rate was observed in January (88.24 %) with average temperature –5.41 ± 2.99 °C. On the contrary, the worst results of conception were found in September (22.73 %), when the average temperature at the time of inseminations reached 16.94 ± 3.61 °C. De Rensis and Scaramuzzi (2003) state that heat stress can affect the course of estral cycle and conception. Any decrease of reproductive abilities in cows during summer is associated with significant economical losses.

Tab. III shows effect of lactation order and temperature on conception, service period and mean daily milk yield. Temperatures at the time of insemination were divided into three intervals (–10.0 to 5.0 °C, 5.1 to 20.0 °C a 20.1 to 27.0 °C).

A total of 263 breeding cows were observed in the experiment. Numbers of cows according to the order of lactation were: 1st lactation – 57 cows, 2nd lactation – 91 cows, 3rd lactation – 68 cows, 4th lactation – 20 cows, 5th lactation – 20 cows and 6th lactation – 7 cows.

Proportion of pregnant cows ranged from 0 % to 42.86 %. The highest overall proportion of pregnant cows was observed in the temperature interval –10.0 to 5.0 °C. An exception are the cows from the category of the 5th lactation, which reached the same conception rates in temperature intervals –10.0 to 5.0 °C and 5.1 to 20.0 °C. The worst conception rates were recorded in the temperature interval 20.1 to 27.0 °C. As mentioned before, III: *Effect of temperature and lactation order on the proportion of pregnant and non-pregnant cows and their mean daily milk yield on the days of insemination*

Order of lactation	Temperature interval	Number of dairy cows (n)	Proportion of pregnant cows (%)	Service period	Daily milk yield of pregnant cows	Daily milk yield of non-pregnant cows
	–10.0 to 5.0		26.32	138.60 ± 56.30	32.14 ±4.88	29.93 ± 1.63
1st	5.1 to 20.0	57	22.81	173.54 ± 39.27	30.18 ± 5.24	32.03 ± 4.44
	20.1 to 27.0		5.26	118.00 ± 29.31	36.83 ± 1.25	38.05 ± 3.25
	–10.0 to 5.0		28.57	126.31 ± 76.92	37.50 ± 5.66	36.62 ± 4.09
2nd	5.1 to 20.0	91	14.29	112.38 ± 42.00	32.34 ± 4.37	35.59 ± 5.96
	20.1 to 27.0		10.99	87.90 ± 23.44	37.82 ± 5.88	39.65 ± 5.14
	–10.0 to 5.0		41.18[a]	132.39 ± 56.67	37.26 ± 6.64	36.02 ± 5.19
3rd	5.1 to 20.0	68	8.82	101.67 ± 45.08	35.50 ± 6.87	38.96 ± 9.72
	20.1 to 27.0		1.47[b]	54.00 ± 0.00	51.40 ± 0.00[A]	39.87 ± 8.11[B]
	–10.0 to 5.0		35.00	116.43 ± 58.15	37.36 ± 5.95	38.05 ± 6.19
4th	5.1 to 20.0	20	15.00	163.00 ± 95.31	29.53 ± 10.53	34.20 ± 0.00
	20.1 to 27.0		10.00	75.00 ± 25.46	43.95 ± 10.39	47.43 ± 7.94
	–10.0 to 5.0		20.00	103.25 ± 45.00	40.83 ± 4.89	40.04 ± 3.22
5th	5.1 to 20.0	20	20.00	141.75 ± 40.24	39.45 ± 5.89	42.15 ± 6.40
	20.1 to 27.0		0.00	-	-	43.70 ± 0.00
	–10.0 to 5.0		42.86	103.33 ± 34.24	36.20 ± 1.21	35.50 ± 0.00
6th	5.1 to 20.0	7	10.71	123.00 ± 0.00	40.90 ± 0.00	43.40 ± 3.25
	20.1 to 27.0		-	-	-	-

a,b – P ≤ 0.05 – difference between temperature effect on pregnancy rates
A,B – P ≤ 0.01 – difference daily milk yield between pregnant and non-pregnant cows

conception rates are better in winter, thus colder, season than in higher temperatures. The comparison of the results from Tab. II and III led to the same conclusions.

The mean daily milk yield of pregnant cows ranged from 29.53 to 51.40 kg and in the non-pregnant cows from 29.93 to 47.43 kg. A statistically significant (P≤0.01) difference was found between the mean daily gain of pregnant and non-pregnant cows from the category of the 3rd lactation in temperature interval 20.1 to 27.0 °C. The mean daily milk yield in the pregnant cows was 51.40 ± 0.00 kg and in the non-pregnant cows 39.87 ± 8.11 kg. This result is probably influenced by the number of only 5 cows in this category with only 1 cow pregnant. On the basis of the data presented in the table, it cannot be confirmed or disproved that cows with higher milk yield are characterized by lower conception rates, as stated by Al-Katanani *et al.*, (1999). The authors found out that the conception rate in cows with milk yield <4536 kg was 44.9 %, in cows with milk yield from 4536 to 9072 kg the conception rate decreased by 13.5 % and in cows with milk yield >9072 the value decreased by 5.3 %. Říha *et al.* (1996) say that increasing performance in animals is associated with decreasing reproductive abilities.

The results of this study also do not confirm of disprove the effect of temperature on mean daily milk yields. The pregnant cows reached higher mean daily milk yield in temperature interval 20.1 to 27.0 °C. The cows from the category of the 5th lactation reached the highest mean daily milk yield in the temperature interval –10.0 to 5.0 °C. In comparison with the temperature interval 5.1 to 20.0 °C, the mean daily yield was higher by 1.38 kg of milk. The difference from the mean daily yield of the pregnant cows from the category of the 6th lactation was 4.7 kg of milk. This difference can be caused by an insufficient number of cows in the observed category.

The non-pregnant cows also reached higher mean daily milk yields in the temperature interval 20.1. to 27.0 °C. These results are absolutely contradictory to the results of West (2003) and Bouraoui *et al.* (2002), who confirmed that heat stress affects the amount of milk produced. Stádník (2003) states that milk production and reproduction of cows are influenced by the type of housing. The author concluded that the dairy cows transferred from tethering to free housing achieved higher mean daily and yearly milk yield. Their reproductive parameters improved as well. The effect of housing and climatic conditions on milk production was studied also by Lambertz *et al.* (2014). They compared results from four types of housing (warm free housing with access to pasture, warm free housing without access to pasture, cold free housing with access to pasture and cold free housing without access to pasture). They found a negative effect of temperature and relative humidity on milk production.

CONCLUSION

Based on the results of this experiment it can be concluded that season of the year and related ambient temperature influence conception in Holstein dairy cows significantly. Cattle belongs to the animals that prosper better in lower ambient temperatures, which was confirmed by the present experiment with higher conception rates recorded in winter season, i.e. in lower ambient temperatures. In winter season, the conception rate was 18.21 % higher than in summer season. The more detailed monthly analysis revealed the best results of the conception rate in January and February. These results document that organism of a dairy cow with high performance, or her reproductive organs, need relatively long time (cca 3 – 4 months) for adaptation to the negative effect of high ambient temperatures and for return of the oogenesis and overall estral cycle to a normal state. This theory is also supported by excellent level of conception yet in June, when the ambient temperatures are higher, however they do not reflect negatively in reproductive functions of cows yet. The most favourable results of conception were observed in temperatures below 5 °C. A part of the experiment was also evaluation of association between daily milk yield and conception rate. It cannot be conclusively confirmed, that cows with lower daily milk yield reach better results in conception, because the milk yield on the day of insemination was mostly similar in both groups of cows (pregnant and non-pregnant).

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