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Effect of heat stress on some reproductive traits in Holstein-Friesian cows under temperate continental climate

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Abstract

The aim of the present study was to determine the effect of heat stress (HS) on some reproductive traits in Holstein-Friesian cows in the central part of southern Bulgaria. The survey was conducted in a dairy cattle farm for the period 2015 - 2018 inclusive, on 155 lactations of cows on first to sixth parity. HS was determined by a modified Kelly and Bond (1971) equation using the maximum temperature (° C) and the average values of relative humidity (%) for each month of the study. Temperature and humidity data were taken from the nearest meteorological station in the area. It was found that Temperature-humidity index (THI) at first insemination had a significant (P <0.05) effect on the length of the Days open interval (DO) and on the number of inseminations for conception (NIC) (P <0.01). Depending on the different levels of THI at first insemination, the DO varies from 130.43 to 206.7 days, respectively for THI below 72 and over 90. The NIC varied from 2.43 to 4.24, respectively, at THI values within of 73-78 and over 90 reported during the month of the first insemination. The highest conception rate (CR) of inseminated cows and the highest conception rate at first insemination (CRFI) were found during the period of mild HS (THI 73-78) 41.7% and 32.5% respectively. With the onset of severe HS months (over 90), these trait values fall to 25% and 26.1%, respectively. In July and August the highest values of THI and the lowest CR 19.4% and CRFI 16.7% were reported. With an increase in THI an increase was observed in the interval between inseminations (IBI) from 35 days at THI below 72 to 45.6 days at THI over 90.

MATERIAL AND METHODS

The study was conducted at a dairy cattle farm in Plovdiv district (Central South Bulgaria- трябва да посочим географското разположение на фермата – ширина, дължина от интернет) for the period 2015 - 2018. The study included all Holstein-Friesian cows calved during this period. Cows were housed in semi-open free stall dairy barn. The average milk yield of the cows on the studied farm was 10 000 kg / lactation. 155 lactations of cows from first to sixth parity were studied. Depending on the number of parities, the cows were distributed in the following order: 48 cows on first, 59 cows on second, 18 on third, 17 on fourth, 9 on fifth and 4 cows on sixth parity. From the herd management software the calving date, the number of inseminations per conception and the dates of all inseminations were taken. From these data for each cow were calculated respectively: interval from calving to first insemination (CFI), DO and IBI.

Heat stress was determined by a modified Kelly and Bond (1971) equation: THI = tmax - (0.55-0.55 RH) (tmax - 58), where: tmax - the maximum measured temperature (in C °) for the studied month, and RH are the average values for relative humidity in % for the studied month. The data on air temperature and humidity for all years of the study needed to calculate the THI were taken from the nearest meteorological station, which was at a distance of 30 km from the surveyed farm.

To obtain a better approximation, some factors were presented in classes as follows: for THI 4 classes were formed: no heat stress - THI up to 72; mild heat stress - THI from 73 to 78; moderate heat stress - THI from 79 to 89 and severe heat stress in THI over 90 (according to Armstrong (1994)); for the season, respectively: 1 - spring (March, April and May); 2 - summer (June, July, August); 3 - autumn (September, October, November) and 4 - winter (December, January and February).

To assess the influence of THI on studied reproductive traits the following model was used:

$\mathbf{Y_{ijkl} = \mu + THI_l + THI_j + THI_k + e_{ijkl}}$

Where:

$\mathbf{Y_{ijkl}}$ - is the dependent variable (OPEN DAYS number of inseminations for conception),

$\boldsymbol{\mu}$ is mean effect, $\mathbf{THI_i}$ is the effect of THI (in classes) on calving, $\mathbf{THI_j}$ is the effect of THI (in classes) on first insemination, $\mathbf{THI_k}$ is the effect of THI (classes) at conception and $\mathbf{e_{ijkl}}$ is the random residual effect.

To assess the influence of THI at insemination on the interval from calving to first insemination a one-way ANOVA was applied, using the following model:

$\mathbf{Y_{ij} = \mu + THI_i + e_{ij}}$

Where:

$\mathbf{Yij = \mu + THIi + eij}$

Where:

$\mathbf{Y_{ij}}$- is the dependent variable (interval from calving to first insemination),

$\boldsymbol{\mu}$ is the mean effect, $\mathbf{THI_i}$ – is the effect of THI (in classes) at insemination and $\mathbf{e_{ij}}$ is the random residual effect.

By analysis of variance (ANOVA) for the model were obtained by classes of the fixed factors the means of least squares (LSM).

For a basic statistical processing of the data a package MS Exsel was used, and for obtaining the average values, errors, and analysis of variance, the corresponding modules of STATISTICA of StatSoft (Copyright 1990-1995 Microsoft Corp.)

RESULTS AND DISCUSSION

Table 1. Average values and variation of the reproductive traits in the studied farm

Trait	Number	x ± SE	SD
Number of inseminations for conception	157	2.89 ± 0.15	1.89
Interval from calving to first insemination (days)	157	73.93 ± 1.78	22.36
Interval between inseminations (days)	278	39.32 ± 1.34	22.37
Days open interval (days)	157	149.89 ± 7.08	88.77

Table 2. Maximal THI values by months for the studied years

Calendar months	2015 THI	2016 THI	2017 THI	2018 THI
1	64	64	64	64
2	64	74	70	64
3	64	74	73	70
4	76	84	78	82
5	82	85	82	76
6	88	91	95	80
7	90	89	91	91
8	89	90	91	87
9	91	86	87	88
10	74	81	77	77
11	73	77	70	74
12	64	64	64	64

Table 3. Analysis of variance for the influence of THI during calving, first insemination and conception on the duration of the Days open interval and the number of inseminations for conception

Sources of variation	Degrees of freedom (n -1)	Days open interval (days)		Number of inseminations for conception	
		MS	F P	MS	F P
Total for the model	3	10262.69	1.32 n.s.	6.36	1.85 n.s.
THI at calving	3	4796.00	0.62 n.s.	6.38	1.86 n.s.
THI at first insemination	3	25842.00	3.34 *	15.45	4.50 **
THI at conception	3	2538.00	0.32 n.s.	2.68	0.78 n.s.
Error	147				

*Significance: * P <0.05; ** P <0.01; *** P <0.001; n.s. - no significance*

Table 4. Analysis of variance for the effect of THI on the length of the IBI

Sources of variation	Interval between inseminations (days)		
	Degrees of freedom (n -1)	MS	F P
Total for the model	3	1401.6	2.86 *
THI	3	1401.6	2.86 *
Error	274		

*Significance: * P <0.05; ** P <0.01; *** P <0.001; n.s. - no significance*

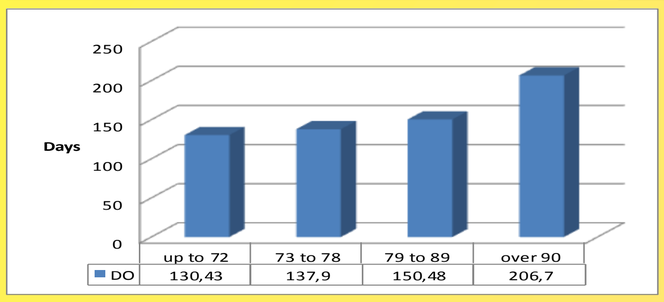

Figure 1. LS-means for the duration of the DO depending on the THI at first insemination

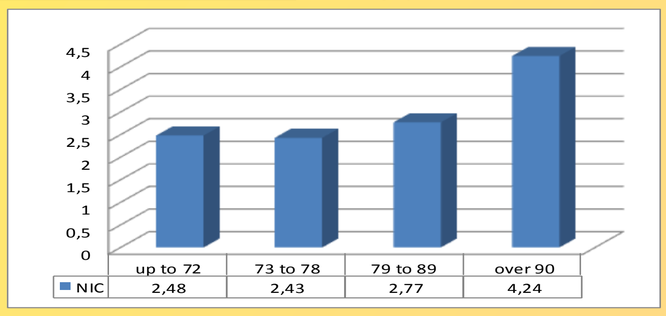

Figure 2. LS-means of NIC depending on THI at first insemination

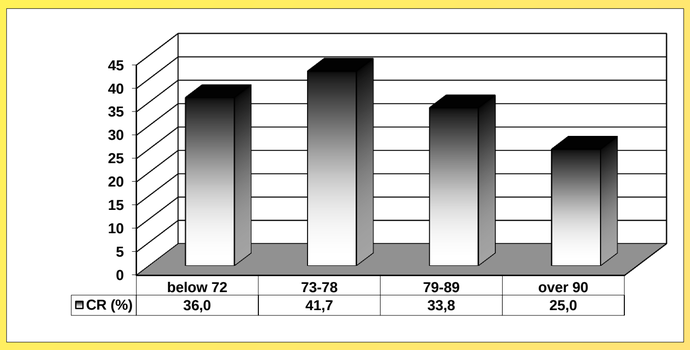

Figure 3. Conception rate of cows depending on the THI class

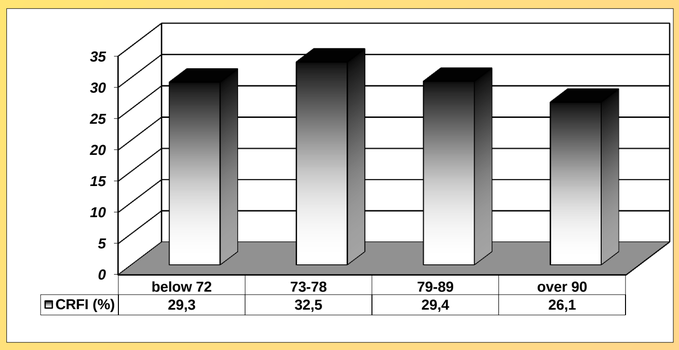

Figure 4. Conception rate at first insemination depending on the THI class

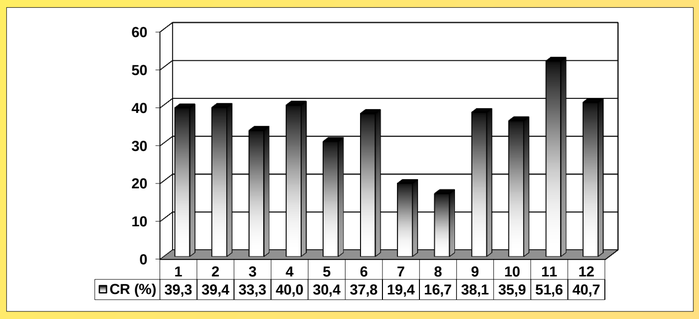

Figure 5. Conception rate by calendar months

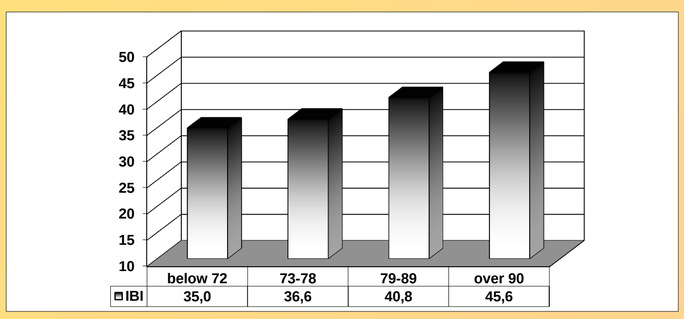

Figure 6. IBI (days) depending on the THI class

Table 1 presents the average values for the reproductive traits of the studied farm. The average number of inseminations for conception was 2.89 ± 0.15, the average duration of IBI was 39.32 ± 1.34 days. The average duration of CFI was 73.93 ± 1.78 days, and the average DO was 149.89 ± 7.08 days. Table 3 presents an analysis of variance for the influence of THI during calving, first insemination and conception on the duration of the Days open interval and the number of inseminations for conception. It was found that THI at first insemination had a significant effect on the duration of the DO (P <0.05). The first insemination of cows usually takes place within 60-66 days after calving, but high values of THI during this period usually reduce the conception rate (Jordan, 2003).

Figure 1 shows the LS-means for the duration of the DO depending on the THI at first insemination. From the data in the figure it can be seen that the cows that were inseminated for the first time at THI up to 72, i.e. in conditions of temperature comfort according to Armstrong (1994) have the shortest DO - 130.43 days. As the values of THI increase, the duration of the DO increased. Under conditions of severe HS (THI over 90) at first insemination, the DO was 206.7 days. When cows were inseminated in such severe climatic conditions of HS, the CR was greatly reduced. Figure 2 shows the LS-means of NIC depending on THI at first insemination. The data show that the NIC does not increase significantly at THI in the range of 72 to 90. There is even a slight decrease in the NIC when comparing conditions without HS (THI below 72) - a value of 2.48 inseminations and in conditions of mild HS (THI from 73 to 78) - 2.43. However, the increase of THI over 90 in the area of the farm we studied caused a significant increase in the NIC to value of 4.24.

Table 4 presents an analysis of variance for the effect of THI on the length of the IBI. It was found that THI had a significant effect (P <0.05) on this trait. Figure 6 shows the IBI in days depending on the THI class. It was reported that with increasing THI the IBI was increasing. Increase between conditions without HS (below 72) and under a mild HS (73 to 78), the increase was a minimal - 1.6 days. With the occurrence of moderate HS (from 79 to 89) this interval reaches 40.8 days or 4.2 days more than the previous period under HS. When severe HS conditions occur, the IBI increased to 45.6 days or 4.8 days longer than the period under moderate HS.

CONCLUSION

The heat stress in dairy cows in the region of Central Bulgaria was manifested from late spring (in May) to early autumn (in September). The highest THI values and respectively HS were reported in the summer (June, July and August). The high THI values at first insemination negatively affect the duration of DO and the IBI. The most substantial increase in these traits was found when the maximum THI values at first insemination were over 90 (under conditions of severe heat stress).

The highest conception rate as well as the highest conception rate at insemination were reported when the cows were under conditions of mild heat stress (THI between 73 and 78). This is probably due to the favorable environmental conditions in the previous months, as well as the cooling carried out on the farm.

The accumulated negative effect of HS in May and June probably affects the development of follicles, due to which in July and August the lowest conception rates in cows were reported. The increase in THI leads to an increase in the interval between inseminations.