Effects of Heat Stress on the Main Reproduction Indices in Romanian Spotted Breed Cows

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Abstract
The aim of this paper was to assess the effects of environmental temperature on the main reproduction indices in Romanian Spotted dairy cows. The study was carried out on 144 Romanian Spotted multiparous cows kept in loose housing throughout the whole year at S.C.D.C.B. Arad. The following traits were analyzed: the voluntary waiting period (from calving to first A.I.), the number of artificial inseminations (A.I.) for a new gestation and interval between calving and new pregnancy, according to the season. Thus, in the winter season, characterized by cold temperatures, but relatively easy incurred by dairy cows, the voluntary waiting period was 51.74 days, and 71.35 days to the new gestation, requiring a number of 1.97 AIs per pregnancy. In spring season, characterized by temperatures near the thermal comfort for cattle, the voluntary waiting period was 56.78 days, 96.71 days until the new gestation, with 2.02 AIs per pregnancy. In summer season, characterized by high temperatures, above the thermal comfort, time to first service was 68.34 days, requiring 100.76 days for the installation of new gestation and using 2.85 AIs per pregnancy. Autumn, season with temperatures well supported by dairy cows, favoured shorter periods to first service 56.84 days. Therefore, only 63.16 days were required for installation of a new gestation, and 2.44 AIs per pregnancy.

Keywords: dairy cows, heat stress, reproduction indices.

1. Introduction

Ambient temperature affects both the main production of dairy cows and reproduction indices. A negative influence exerted on them, leads inevitably to an inconstancy productive activity, with effects in farm business profitability. High temperatures from the summer negatively affect the growth and development of the luteal body and entire endocrine activity [1]. Decreasing the endocrine activity, under the action of heat stress will result in default, to reduction of follicular development and embryo [2,3]. High temperatures, out of optimal thermal limit, can cause syncope in placenta development, increase foetal hypoxia incidence [4].
Aim of this work was to assess the effect of season on the main reproduction indices.

2. Materials and methods

The investigations were carried out at the Research and Development Station for Bovine Arad (S.C.D.C.B. Arad) on a 144 Romanian Spotted multiparous cows, from January 2013 to December 2013.
The following reproduction indices have been studied: voluntary waiting period (from calving to 1st A.I.), interval between calving and new pregnancy (days open) and the number of artificial inseminations (A.I.s) for a new gestation. Previously listed indexes, have been studied in

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terms of influence exercised upon them, the ambient temperature. Data were collected during the whole year, statistical processing and testing emerging differences being made on monthly intervals within the same season and separately, for all those four seasons.
Milk production corrected depending on the rank of the lactation, is between 5200-5700 L/ normal lactation. In relation to milk production and body condition of cows, duration of the voluntary waiting period was set at 45 days. On the basis of this interval range, the actual range of this interval have been observed and recorded, separately for each month and each season, the differences being put into the ambient temperatures account. Also, the ambient temperature was measured. Reported to the ambient temperature the time required for the installation of the new gestation, as well as the number of A.I.s was recorded individually for each animal.
Statistical calculations was carried out in order to establish if there are any differences among seasons on selected reproduction indices.

3. Results and discussion

Ambient temperature is one of the factors that have a great influence on the dairy cows' production, but also on their reproduction indices.
Thermal values by months of the year are displayed in Table 1.
Daily ambient temperatures have been recorded, evolution during the trial is shown in Figure 1.

Table1. Thermal values reported by the months of the year

Month	Jan	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature t°C	2.8	4.6	6	9.2	14.4	17	23.1	29.4	21	17.6	10.5	4.4

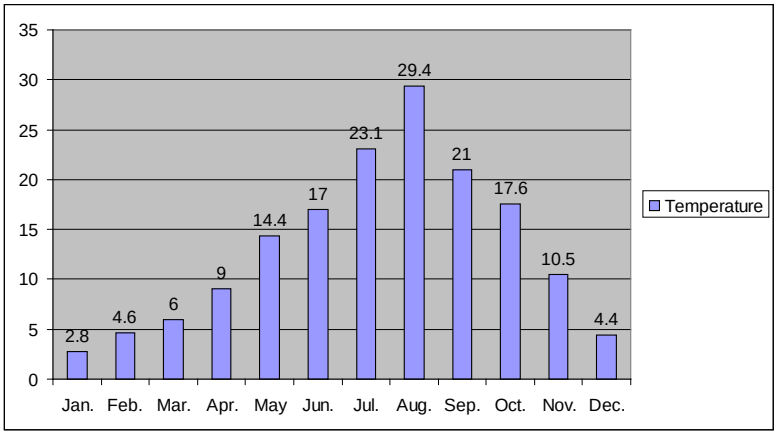

Figure1. Ambient temperatures evolution, during a year

The first index taken in the study was voluntary waiting period, representing the interval between calving and the first A.I. Results obtained are shown in the Table 2.

Table 2. Average and dispersion indices for the voluntary waiting period (V.W.P.)

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Milk yield (kg)	5315	5288	5412	5481	5905	6012	5980	6220	5876	5443	5560	5346
No. of cows	9	15	13	15	10	16	16	14	8	7	10	11
Days in V.W.P.	49	49.55	48	59.11	67.77	72.33	71.11	66.22	64.62	55.57	50.77	55.55
	±6.43	±3.24	±5.02	±6.87	±2.44	±5.87	±4.57	±4.81	±5.36	±10.77	±8.03	±3.08
V%	39.42	25.32	37.77	45.03	11.42	32.47	25.76	27.22	23.49	51.27	50.36	18.42

Studying the data presented in Table 2, it is clear that the trend was to exceed the set value for voluntary waiting period of 45 days. Cows that calved during the winter months, had an overrun of this period much shorter (49 to 56 days) than those calved in the summer months and which have been exposed to heat stress (66 to 72 days). Cows that have calved during the beginning of

spring (March, April) showed a close duration of this interval to that established initially, compared to those in the autumn months. Cows calved in spring had the late gestation in months with low temperatures, compared with those calved in autumn witch had the late gestation in warm months. Cows calved in the warm months of the year, presented, in generally a longer voluntary waiting period. Even for cows calved in June, for example, the range of this period has remained long, due to the heat stress to which the dairy cows have been exposed in the period immediately following to those months, those months being the warmest months of the year, July and August.

Table 3 presents the differences and statistical significance for voluntary waiting period between months of the year.

Table 3. Differences and statistical significance of voluntary waiting period (days), reported by calendar months

Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan	-.055NS	1NS	-10.11NS	-18.77S	-23.33S	-22.11S	-17.22S	-15.62NS	-6.57NS	-1.44NS	-6.55NS
Feb	-	1.55NS	-9.56NS	-18.22VS	-22.78DS	-21.56S	-16.67DS	-15.07S	-6.02NS	-0.89NS	-6NS
Mar	-	-	-11.11NS	-19.77DS	-24.33DS	-23.11S	-18.22S	-16.62S	-7.57NS	-2.44NS	-7.55NS
Apr	-	-	-	-8.66S	-13.22S	-12NS	-7.11NS	-5.51NS	3.54NS	8.67NS	3.56S
May	-	-	-	-	-4.56NS	-3.34NS	1.55NS	3.15NS	12.2S	17.33DS	12.22S
Jun	-	-	-	-	-	1.22NS	6.11NS	7.71NS	16.76S	21.89S	16.78S
Jul	-	-	-	-	-	-	4.89NS	6.49S	15.57DS	20.67VS	15.56DS
Aug	-	-	-	-	-	-	-	1.6NS	10.65S	15.78DS	10.67S
Sep	-	-	-	-	-	-	-	-	9.05NS	14.18NS	9.07NS
Oct	-	-	-	-	-	-	-	-	-	5.13NS	0.02NS
Nov	-	-	-	-	-	-	-	-	-	-	-5.11NS

NS – non significant ($p>0.05$), S – significant ($p<0.05$), DS – distinctly significant ($p<0.01$), VS – very significant ($p<0.001$)

Analysing data in Table 3, shows significant differences concerning the range of voluntary waiting period, between cows calved in months with low temperatures and those calved in months with warmer temperatures. Between cows calved in June and those calved in the autumn months (October and November), the differences were significant. Generally, cows calving in autumn (September to November) were not expose to intense heat stress compared to cows calved in July-August, therefore differences between these months were statistically significant. When cows calved during months with ambient temperatures close to the optimal thermal range (12-15°C), differences were not significant, i.e. October and February.

The average values and dispersion indices of voluntary waiting period intervals, calculated for each season in part, are shown in Table 4.

Table 4. Average and dispersion indices for the voluntary waiting period, reported by the season

Parameters	Winter (Dec+Jan+Feb)	Spring (Mar+Apr+May)	Summer (Jun+Jul+Aug)	Autumn (Sep+Oct+Nov)
No. of cows	35	38	46	25
Days in V.W.P.	51.74±2.49	56.78±3.12	68.34±2.98	56.84±4.57
V%	28.57	33.86	29.65	40.2

There were very significant differences between the voluntary waiting period of cows calved in winter and those calved in summer, with 16.6 days shorter in winter ($p<0.001$, Table 5). Also, the summer calving cows had significantly longer voluntary waiting periods compared to spring calving cows (11.56 days, $p<0.01$) and compared to autumn calving cows (11.5 days, $p<0.05$).

Table 5. Differences and statistical significance of voluntary waiting period, reported to season

Season	Spring	Summer	Autumn
Winter	-5.04NS	-16.6VS	-5.1NS
Spring	-	-11.56DS	-0.06NS
Summer	-	-	11.5S

NS – non significant ($p>0.05$), S – significant ($p<0.05$), DS – distinctly significant ($p<0.01$), VS – very significant ($p<0.001$)

Regarding the interval from calving to installation of a new gestation (days open), this reproductive index tended to follow somehow the monthly temperature evolution curve. Table

6 shows the average values and dispersion indices, for this index.

Table 6. Average and dispersion indices regarding needed interval for a new gestation

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of cows	9	15	13	15	10	16	16	14	8	7	10	11
Days open	66.56 ±6.63	78.23 ±10.23	77.18 ±6.72	81.30 5±8.66	95.00 ±14.39	97.94 ±9.78	104.00 ±11.10	100.50 ±12.19	70.25 ±5.61	54.14 ±6.57	63.80 ±6.58	64.63 ±4.98
V%	29.91	53.96	28.91	39.85	47.92	41.2	42.71	45.38	22.59	32.12	32.65	25.57

From the analysis of data in Table 6, we observed the Gaussian distribution of the days open, being higher for cows calved in the summer months, when the average temperatures values constituted a stress factor and lower for cows calved in the winter months with low temperatures or for those calved in spring and autumn, months with temperatures near to the thermal optimum. The maximum value for these indices was found for cows calved in July and the minimum for those calved in October. We can state that cows whose calvings were preceded and followed by high ambient temperatures, will have a prolonged days open, compared with those whose calvings took place in the cooler periods of the year. The effect of heat stress in dairy cows over the latter part of pregnancy and the period immediately postpartum, can be extend over different periods of time, depending on the individuality of animals. Thus, we observe from the data presented in Table 6, higher values for days open in cows calved in April-May followed by periods characterized by high temperatures in months of June to August. Low values for days open in cows calved in October-February, are explained by the low temperatures of the months preceding or following the calving. The trend for decreasing values of days open was encountered as early as in August, even if the length of days open was still great. In this case, the effect of heat stress in the months of June and July still remain for a period of 40-60 days, only in the case of cows calving in September and May we can talk about a substantial reduction of days open.

Differences for days open and their statistical significance are shown in Table 7.

Table 7. Differences and statistical significance regarding the days open, reported to months

Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan	-11,67NS	-10,62NS	-14,79S	-28,44S	-31,38S	-37,44S	-33,94S	-3,69NS	12,42NS	2,76NS	1,93NS
Feb	-	1,05NS	3,12NS	16,77S	19,71S	25,77DS	22,27DS	7,98NS	24,09DS	14,43NS	13,6NS
Mar	-	-	-4,17NS	-17,82S	-20,76DS	-26,82DS	-23,32S	6,93NS	23DS	13,38S	12,55S
Apr	-	-	-	-13,65NS	-16,59S	-22,65S	-19,15S	11,1NS	27,21DS	17,55S	16,72S
May	-	-	-	-	-2,94NS	-9NS	-5,5NS	24,75S	40,85DS	31,2S	30,37S
Jun	-	-	-	-	-	-6,06NS	-2,56NS	27,69S	43,8DS	34,14S	33,31S
Jun	-	-	-	-	-	-	3,5NS	33,7DS	49,85VS	40,2DS	39,37DS
Aug	-	-	-	-	-	-	-	30,25S	46,36DS	36,7S	35,87S
Sep	-	-	-	-	-	-	-	-	16,11S	6,45NS	5,62NS
Oct	-	-	-	-	-	-	-	-	-	-9,66NS	-10,49NS
Nov	-	-	-	-	-	-	-	-	-	-	-0,83NS

NS – non significant ($p>0.05$), S – significant ($p<0.05$), DS – distinctly significant ($p<0.01$), VS – very significant ($p<0.001$)

From analysis of the data presented in Table 7, results that the intervals are different, depending on the temperatures characteristic for each months of the calving. Thus, as the average monthly temperature increases, the values of the days open increase. Therefore, significant differences were observed between days open for cows calved in the cold or intermediate months, from September to April, on one hand and cows calved in the summer months, from June to August, on the other hand. Thermal influence was strong, so that during the months from May to August non-significant differences appeared, which demonstrates that dairy cows are very sensitive to temperature increases, even those increases are small, as the case of month of May. Between autumn, characterized by intermediate temperatures and winter, with low temperatures, the differences were not statistically significant. This was not the case when summer and winter months were compared for days open, differences being statistically significant. Again, these differences showed that the high temperatures constitute a major stress factor for dairy cows. The average values for days open are shown in Table 8, and Table 9 presents the differences and their statistical significance between seasons. The differences

between seasons for days open appeared due to the average monthly temperatures during the postpartum period.

Table 8. Average and dispersion indices for days open, reported to season

Parameters	Winter (Dec+Jan+Feb)	Spring (Mar+Apr+May)	Summer (Jun+Jul+Aug)	Autumn (Sep+Oct+Nov)
No. of cows	35	38	46	25
Days open	71.35±5.19	96.71±7.46	100.76±6.19	63.16±3.75
V%	44.27	45.66	42.15	29.72

Table 9. Differences and statistical significance for days open, reported to season

Month	Spring	Summer	Autumn
Winter	-25.36DS	29.41VS	8.19NS
Spring	-	4.05NS	33.55DS
Summer	-	-	37.6VS

NS – non significant ($p>0.05$), S – significant ($p<0.05$), DS – distinctly significant ($p<0.01$), VS – very significant ($p<0.001$)

Cows calved during the winter, with low average temperatures, both before and after calving, had the ability to express more obviously their sexual specific manifestations, reason leading to shorter days open. At the opposite pole, were the cows with late gestation and postpartum period during the warm summer season, whose thermal average exceeds by far the optimum thermal comfort. In this category we can include those cows that calved in the late spring and summer, showing relatively long days open, due to high temperatures acting as an inhibitor of the specific sexual behaviour. Numerous cases of silent heats, the lack of specific sexual behaviour, or lack of heats lead to extensions of days open, proportionally with duration and intensity of the stressor factor. The lowest values for days open were found in cows calved in autumn, which benefit from low temperatures during postpartum period, were not exposed to heat stress at the time of sexual cycle resumption. Statistically significant differences for days open were found between winter/autumn and the spring/summer seasons. Also, statistically significant differences were found between winter and autumn seasons.

Extending the days open, determines, in most of the cases, at increase in the number of A.I.s needed for a new gestation. This is due to diminished intensity of the reproduction specific activity. Of course, the intensity of specific processes is much reduced under high temperatures. Thus, we can speak of problems relating to lack of ovulation, sexual behaviour and problems in nidation and hormonal synthesis.

Table 10. Average and dispersion indices regarding A.I.s needed for a new gestation

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No of cows	9	15	13	15	10	16	16	14	8	7	10	11
No. of	2	2.26	1.69	2	2.5	2.75	3	2.8	2.75	2.28	2.3	2.27
A.I.s/gestation	±0.33	±0.15	±0.13	±0.13	±0.16	±0.25	±0.22	±0.34	±0.31	±0.18	±0.33	±0.3
V%	26.26	28.38	26.72	21.08	36.36	29.81	47.14	32.23	21.4	46.05	44.45	42.17

Demand for semen increases with ambient environment temperature. Thus, the cows calved in summer requires a larger number of A.I.s (2.75-3 A. I.s/gestation, June to September, Table 10) compared with those calved in winter or spring (1.69-2.3 A.I.s/gestation, October to April, Table 10). The maximum number of A.I.s for one pregnancy was required for cows calved in July, due to high temperatures, while the cows calved in March, when the environmental temperatures were close to optimum thermal comfort, required only 1.69 A.I.s/gestation.

Table 11 presents the differences between months regarding the number of A.I.s/gestation, during the year 2013.

The number of A.I.s required by dairy cows calved during the winter months was not significantly different from that of cows calved in the spring and autumn months. Significant differences were found between the spring and the summer months.

Compared to autumn, when the postpartum months were characterized by low temperatures, cows that calved during the spring months, had a

slightly increased number of A.I.s/gestation, due to the warm months succeeding the parturition. Differences between the spring and autumn season were significant, even if they could vary from statistically non-significant to significant. The hot season months, including June, July and August, as well as the beginning of September, required the highest number of A.I.s/gestation, these values being significant in comparison to autumn, spring and winter months. The highest differences occurred between February to April on one hand and June to September on the other hand.

Table 11. Differences and statistical significance regarding A.I.s needed for a new gestation

Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan	-026 NS	0.31NS	0NS	0.5NS	0.75S	1S	0.8S	0.75S	0.28NS	0.3NS	0.27NS
Feb	-	0.57DS	0.26S	-0.24S	-0.49S	0.74DS	-0.54DS	-0.49S	-0.02NS	-0.04NS	-0.01NS
Mar	-	-	-0.31NS	0.81DS	-1.06VS	-1.31VS	1.11VS	1.06VS	0.59S	0.61S	0.58S
Apr	-	-	-	-0.5S	-0.75S	-1VS	-0.8S	-0.75S	-0.28NS	-0.3NS	-0.27NS
May	-	-	-	-	-0.25NS	-0.5S	-0.3S	-0.25NS	0.22NS	-0.2NS	0.23NS
Jun	-	-	-	-	-	-0.25NS	-0.05NS	0NS	0.47S	0.45S	0.48S
Jun	-	-	-	-	-	-	0.2NS	0.25NS	0.72S	0.7S	0.73DS
Aug	-	-	-	-	-	-	-	0.05NS	0.52DS	0.5DS	0.53DS
Sep	-	-	-	-	-	-	-	-	0.47NS	0.45NS	0.48NS
Oct	-	-	-	-	-	-	-	-	-	-0.02NS	0.01NS
Nov	-	-	-	-	-	-	-	-	-	-	0.03NS

NS – non significant (p>0.05), S – significant (p<0.05), DS – distinctly significant (p<0.01), VS – very significant (p<0.001)

Summarizing, the highest number of A.I.s/gestation was required in the summer, followed by the season of autumn, spring and winter (Table 12). Differences for the number of A.I.s/gestation between seasons were obvious and are presented in Table 13.

Table 12. Average and dispersion indices regarding A.I.s needed for a new gestation, reported by the season

Parameters	Winter (Dec+Jan+Feb)	Spring (Mar+Apr+May)	Summer (Jun+Jul+Aug)	Autumn (Sep+Oct+Nov)
No of cowst	35	38	46	25
No. of A.I.s/gestation	1.97±0.14	2.02±0.09	2.85±0.15	2.44±0.17
V%	43.47	29.22	37.27	35.65

Table 13. Differences and statistical significance regarding A.I.s/gestation, reported by season

Season	Spring	Summer	Autumn
Winter	-0.05NS	-0.88VS	-0.47S
Spring	-	-0.83VS	-0.42S
Summer	-	-	0.41S
Autumn	-	-	-

NS – non significant (p>0.05), S – significant (p<0.05), DS – distinctly significant (p<0.01), VS – very significant (p<0.001)

4. Conclusions

Ambient temperature strongly influences both the main productions (milk, chemical composition of milk) and reproduction indices.

Extension of the voluntary waiting period over the limit set, depending on the milk production and body condition of cows, as well as longer days open, represents a negative effect of exceeding the optimal thermal comfort (12-15°C).

The extension of these two intervals, automatically lead to lengthening the calving interval between two successive calvings, with adverse effects on constancy and rhythmicity of milk production on the entire active life. High temperatures in the summer months lead to increases of these intervals.

Low temperatures in winter or spring and autumn seasons, maintain these intervals within physiologically limits.

Effect of high temperature did not cease when ambient temperature decrease, but its effect remain for longer or shorter periods. Thus, cows calved in the early part of autumn present longer intervals, caused by residual effect of the heat stress those were expose to during the summer season. Cows calved toward the end of spring, which in the next postpartum period will face high temperatures caused by the imminent arrival of the summer, present longer voluntary waiting period

and days open. Therefore, we can conclude that dairy cows are animals highly sensitive to temperature oscillations, especially to increase in temperature.

Exceeding the optimal thermal comfort, the number of A.I.s/new gestation increase due to the negative effects of heat on specific reproduction activity.

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