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Environmental effects on reproductive performance of Nellore cows widely raised in the Cerrado/Pantanal ecotone

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ABSTRACT. We analyzed the pregnancy rate (PR) and birth rate (BR) of Nellore cows raised extensively in the Cerrado/Pantanal during 4 mating seasons (2009–2012), assessing the relationship with the temperature and humidity index (THI) and the effect of the year and breeding season. We used information from 2,116 cows, which were categorized as either multiparous (n = 1430), primiparous (n = 338), or nulliparous (n = 348). In the months of the breeding season (December–February), temperature and relative humidity data were collected to calculate the temperature and humidity index (THI). An ANOVA was performed with a model that included sources of variation from the fixed effects of category of cow and year on PR and BR; and a linear regression analysis and correlation between THI and PR and BR. We observed a significant effect ($p < 0.05$) on PR. We classified the average across breeding seasons as a moderate THI. The THI of the breeding seasons showed high and significant ($p < 0.05$) effects only on the nulliparous BR, and low values in other categories. It is concluded that the seasonal THI was not related to the performance of cows, except BR in nulliparous cows.

Keywords: beef cattle, environmental effect, reproductive efficiency.

Interação do ambiente com desempenho reprodutivo de matrizes Nelores criadas extensivamente no ecótono Cerrado/Pantanal

RESUMO. Analisou-se taxa de prenhez (TP) e de natalidade (TN) de matrizes Nelores criadas extensivamente no Cerrado/Pantanal, acasaladas durante 4 estações de monta natural (2009 a 2012), avaliando relação com índice de temperatura e umidade (ITU) e efeito do ano da estação de monta. Utilizaram-se 2.116 informações de matrizes, pertencentes às categorias de multíparas (n = 1430), primíparas (n = 338) e nulíparas (n = 348). Nos meses de estação de monta (dezembro a fevereiro) coletaram-se informações da temperatura e umidade relativa do ar, para o cálculo de índice de temperatura e umidade (ITU). Realizaram-se análise de variância com um modelo contendo como fontes de variação os efeitos fixos de categoria e ano de estação de monta sob a TP e TN; e análise da regressão linear e correlação entre o ITU e a TP e TN. Observaram-se efeito significativo ($p < 0,05$) de categoria sob a TP. Classificou-se o ITU médio entre as estações de monta como moderado. O ITU das estações de monta apresentou relação alta e significativa ($p < 0,05$) apenas na TN das nulíparas, e baixas tendências de relação com as demais. Conclui-se que o ano da estação de monta e o ITU não apresentaram relação com desempenho das matrizes, exceto as nulíparas considerando ITU e TN.

Palavras-chave: bovino de corte, efeito ambiental, eficiência reprodutiva.

Introduction

In a beef cattle production system, the reproductive performance of females is essential for maximum profitability (Santos et al., 2011). Beretta, Lobato & Mielitz Netto (2001) reported that the birth rate of breeding animals is the variable that causes the greatest impact on profitability within a production system. According to Abreu et al. (2003), when the birth rate increases from 65 to 70%, it raises the number of sold animals by 16.3% on average.

Several authors have presented results on the reproductive and productive performance of Nellore herds subjected to different production systems, identifying and evaluating biological rates in different Brazilian regions (Grecellé et al., 2006;

Silveira et al., 2004; Vieira et al., 2006). However, few studies on pure or crossed Nellore cattle are related to how pregnancy and birth rates are affected by temperature and humidity and breeding season.

Silva et al. (2006) reported that animals in tropical environments with high temperatures, low air humidity, and high radiation might have lower efficiency of heat loss, generating stress. Ferro et al. (2010) reinforced that environmental factors could affect production in various circumstances, affecting the reproductive performance of an animal.

Silva et al. (2010); Torres-Júnior et al. (2008); (Vasconcelos et al., 2006) found that, through this stress, there is a limitation in both the development of the animal as well as in its productive and reproductive efficiency. Neiva et al. (2004) point out that the interaction between animal and environment should be taken into consideration when seeking greater efficiency in livestock farming, as the knowledge of climatic variables and their action on the animals behavioral and physiological responses are important to the appropriateness of a production system matching the goals of the cattle industry.

The temperature and humidity index (THI), calculated through the combination of temperature and humidity (Thom, 1959) is one of the environmental factors that has been related to the thermal comfort of animals, and may or may not influence the productive and reproductive performance of cattle (Azevedo et al., 2008; García-Ispierto et al., 2007; Neiva et al., 2004; Nóbrega et al., 2011; Ricci & Domingues, 2013).

This study aims to analyze the reproductive performance of Nellore cows in an extensive system in the Cerrado/Pantanal ecotone, thus evaluating the effect of the breeding season and the relationship of temperature and humidity (THI) on pregnancy and birth rates.

Material and methods

Information was collected on 2,116 Nellore cows that were either multiparous (n = 1,430), primiparous (n = 338), or nulliparous (n = 348). The cows were bred extensively in a property located in the municipality of Aquidauana, Cerrado/Pantanal ecotone of Mato Grosso do Sul State, Brazil. This region has a climate classified as Aw according to Köppen and Geiger, with an average temperature of 25°C and average annual rainfall of 1,450 mm, with the rainy season from October to March and the dry season from April to September.

The bull:cow ratio in the study property is 1:25. The forage used in pasture is *Brachiaria brizantha*, with a total area for grazing of 600 hectares, being distributed in a greenhouse of 20 to 30 hectares, with weekly rotational grazing.

To analyze the rate of pregnancy, a pregnancy diagnosis was performed through the rectal palpation method 60 days after the end of the mating season, performed via natural mating between December and February from 2009 to 2012. Data were collected on the population of cows that entered the mating season by category, the number of cows that were not pregnant, and the number of pregnant cows, noting the pregnancy percentage in each category at the end of each year (Table 1).

The birth rates were calculated as the number of calves born divided by the number of examined females, multiplied by 100. During the mating season, information was collected on the monthly average maximum temperature in degrees Celsius (T) and air relative humidity (RH), to find the maximum THI (THImax), and the minimum monthly temperature and relative humidity to obtain the minimum THI (THImin) through the model defined by Thom (1959):

$$THI: (0.8 \times T + (RH(\%)/100) \times (T - 14.4) + 46.4)$$

Then, the average THI (THI med) was estimated as:

$$THI\ med = ((THI\ max + THI\ min)/2)$$

Information derived from the THI index indicating the monthly values (December 2008 to February 2012) during the four mating seasons are presented in Table 2.

Table 1. Summary of Nellore pregnancy rates in different categories, from 2009 to 2012.

Year	Multiparous cows				Primiparous cows				Nulliparous			
	T.	E.	*P.*	%	T.	E.	*P.*	%	T.	E.	*P.*	%
2009	305	25	280	92	87	24	63	72	105	7	98	93
2010	359	41	318	89	97	29	68	70	78	0	78	100
2011	368	57	311	85	77	07	70	90	87	09	78	90
2012	398	76	322	81	77	16	61	79	78	8	70	90
T.	1430	199	1231	87	338	76	262	78	348	24	324	93

*T.: total; E.: empty; P.: pregnant; %: percentage of positive pregnancy rate.

Table 2. Meteorological data during the months of the mating seasons, from December 2008 to February 2012.

Year	Date	Temp. (°C)		Humid (%)		THI			TR
		Min.	Max.	Min.	Max.	Min.	Max.	Med.	mm
	Dec 2008	22	35	36	91	67	94	80	93
1	Jan 2009	22	33	47	94	67	90	78	56
	Feb 2009	23	34	46	95	68	92	80	66
	Dec 2009	24	33	65	89	71	89	80	324
2	Jan 2010	23	33	63	90	71	89	80	304
	Feb 2010	24	34	60	88	72	91	81	82
	Dec 2010	23	34	46	91	69	92	80	132
3	Jan 2011	23	33	54	94	69	90	79	351
	Feb 2011	23	32	57	95	70	89	80	247
	Dec 2011	22	35	37	89	67	93	80	80
4	Jan 2012	23	34	49	93	68	92	80	123
	Feb 2012	22	34	45	94	68	92	80	115

Temp.: temperature; Humid.: relative humidity; THI: temperature and humidity index; TR: total rainfall in the month (CEMTEC, 2014).

A statistical analysis was performed using the method of minimum squares, with a statistical model containing the sources of variation as the fixed effects of the category and year of the mating season, as well as the random effects and error.

$$Y_{ijk} = \mu + C_i + E_j + e_{ijk}$$

Y_i = Observed effect rate in the cows; μ = General average of the feature; C_i = Cow category (i = multiparous, primiparous, or nulliparous); E_j = mating season (j = 2008 to 2009, 2009 to 2010, 2010 to 2011, 2011 to 2012); and e_{ijk} = random error assuming a normal distribution with an average equal to zero and variance σ^2.

The analysis of the relationship between the pregnancy and birth rates and THI med was performed using linear regression: Y = A + BX, where Y is the pregnancy rate for a category of cow, A is the linear coefficient, B is the angular coefficient, and X represents the THI med in the mating seasons, with significance determined at 5% probability. The values of the correlation coefficient were determined in regression analyses.

Results and discussion

The only significant effect ($p < 0.05$) in the results was the relationship of cow category on pregnancy rates (Table 3), with nulliparous cows having the highest pregnancy rate.

Batista et al. (2012) found that multiparous and primiparous cows had greater dispersion of their reproductive index values around the average, indicating that these two categories of cows are more dependent on their environment.

Grecellé et al. (2006), Vieira et al. (2005) observed an increase in the pregnancy rate of beef cows, related to improvements in body condition score. Vieira et al. report that cows between their third and eighth delivery had better pregnancy rates, delivery intervals, and weight of calves at weaning; the last variable was also observed in studies of Bocchi et al. (2004), Conceição et al. (2005) and Souza et al. (2004).

Suggested strategies for the recovery and accumulation of organic reserves of multiparous and/or primiparous cows include the designation of quality pastures and the temporary removal of calves along with hormone treatment with a progesterone-releasing intravaginal device (Ereno et al., 2007), allowing cows to reach appropriate body conditions to return to the mating season.

Vaz, Lobato & Restle (2010) reported that the early weaning of calves at 76 days of age allowed a greater weight recovery post-weaning and longer reproductive periods in beef cows, thereby improving their body condition and increasing the rate of pregnancy compared to cows that continued nursing until 148 days of age. However, Pötter & Lobato (2004) reported that, without proper nutrition management that presented a high direct relationship with the pregnancy rate, early weaning did not increase the rate significantly.

Santos et al. (2009) observed that, for cows raised in Pantanal, a plan for strategic nutritional management in the pre- and post-partum periods, associated with the selection of cows adapted to regional bioclimatic conditions, increased the likelihood of producing a calf each year. Therefore, it is understood that this strategy could be used in other tropical regions.

Abreu et al. (2006) suggested, as a control of cows' reproductive efficiency, the implementation of artificial insemination, bringing with it the establishment of the mating season, making it possible to identify cows with lower reproductive performance, with the probability of discarding 16 times higher when compared to the traditional system, facilitating the targeting of selection for fertility of the cows and the increase in nulliparous and primiparous cows selected for reproductive efficiency in the bred flock.

Table 3. Summary of variance analysis of the pregnancy rate of Nellore cows in the Cerrado/Pantanal Ecotone.

	Pregnancy Rate	VC%	Birth Rate	VC%
Season				
1	88.73 ± 10.50 A	12.15	63.78 ± 11.00 A	17.26
2	86.89 ± 15.08 A	17.50	75.31 ± 15.87 A	21.08
3	86.27 ± 3.38 A	3.83	85.57 ± 3.79 A	4.44
4	81.91 ± 5.65 A	6.79	80.87 ± 7.24 A	8.96
Category				
Multiparous	86.75 ± 4.78 AB	5.52	85.82 ± 7.31 A	8.52
Primiparous	77.75 ± 9.03 B	11.62	70.93 ± 14.63 A	20.63
Nulliparous	93.25 ± 4.71 A	5.06	72.40 ± 10.52 A	14.53

*Same letters indicate no statistical significance by the Tukey's test at 5% significance. VC%: variation coefficient.

Extremes in the THI indicate the minimum or maximum energy expenditure used for thermoregulatory mechanisms, since for each species there is a thermal comfort level in which the animals demonstrate their best performances (Azevedo et al., 2008). According to Perissinotto et al. (2007), animals are biological machines, able to express their full potential under optimal environmental conditions.

Using the THI classification proposed by Armstrong (1994), in which mild or low heat stress is considered for values between 72 and 78, moderate to severe between 79 and 88, and severe between 89 and 98, extremes of THI min (67.33) and THI max (92.33) among the mating seasons indicated mild and severe heat stress, respectively (Figure 1). The THI med (79.08) was ranked as moderate. A lower value of THI min was observed in the 2009 mating season, and there was an increase in THI max in the 2012 mating season.

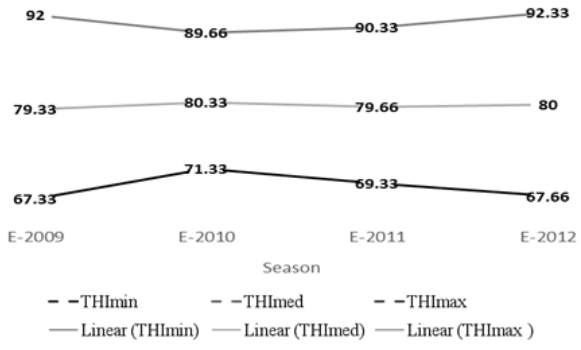

Figure 1. Behavior of THI min, THI med, and THI max during the mating seasons.

According to Souza et al. (2004), animals in warm regions can store heat in an attempt to keep a thermal equilibrium, seeking the minimum use of the thermoregulatory system.

In this sense, knowledge of the tolerance and capacity of various species and breeds as a form of technical support to a particular animal use is necessary to develop genotypes more suitable for a specific environmental condition (Nóbrega et al., 2011).

Azevedo et al. (2005) found that ½ Dutch and Zebus cows showed greater tolerance to heat than 7/8 Dutch and Zebus cows. Azevedo et al. (2008) examined the THI considered stressful in evaluating the adaptability of the Pé-duro cattle breed to climatic conditions of the semi-arid region of Piauí State, finding that the breed was adapted to the region. Batista et al. (2012) found that multiparous and primiparous cows had greater dispersion of their reproductive index values around the average, indicating that these two categories of cows are more dependent on the environment to which they are subjected.

Passini et al. (2009) found that animals kept under thermal stress reduced their total dry matter intake without changing the concentration of calories or fiber in their diets, probably in an attempt to keep a stable ruminal environment. Toledo et al. (2007) found a negative correlation between the THI and the maximum value of the time it took neonatal Nellore calves to stand up and breastfeed; calves born when the THI was lower had a latency time to standing up higher than 100 minutes, suggesting that the thermal comfort zone of newborn calves is at higher temperatures.

Analyzing Table 4, it was observed that there was no significance ($p < 0.05$) for values of linear regressions between pregnancy rate and THI med, indicating overall only a minor influence. As for the birth rate, a high and significant relationship ($p < 0.05$) was observed between the THI med and nulliparous cows.

Table 4. Linear regression equation for the pregnancy rate and the THImed of the mating season (2009 to 2012), with the coefficient of determination (R^2) and Pearson's (r) correlation coefficient.

Category	R^2	r	(p)
	THImed – Pregnancy rate		
Multiparous	0.12	0.35	0.646
Primiparous	0.24	0.49	0.748
Nulliparous	0.03	0.19	0.572
	THImed – Birth rate		
Multiparous	0.06	0.24	0.752
Primiparous	0.01	0.11	0.882
Nulliparous	0.96	0.98	0.019*

*$p < 0.05$.

The possible low tendency of the ratio between the THI and pregnancy and birth rates, as well as calf weaning, may be related to the breed used, since the Nellore is a type of Zebu, and therefore has high comfort and adaptability to the tropics due to its body structure and higher number of sweat glands.

On the other hand, this justification diverges from results obtained by Azevêdo et al. (2006) for which the authors concluded that the reproductive performance of Nellore females from herds in the North and Northeast of Brazil (a tropical region) falls short of the ideal.

It is suggested that, despite the weak relationship between the THI and the pregnancy and birth rates and weaning, other variables, such as appropriate nutritional management and other sources of non-genetic variation (birth year, birth month, age of the cow, or year of birth), become relevant for the productive and reproductive efficiency.

Conclusion

No effect of the mating season on pregnancy and birth rates was observed in the cows, and the only differences between types of cows were in the pregnancy rate. Primiparous cows were less efficient, contributing to the decrease in the herd's pregnancy and birth rates. In general, the THI med remained moderate, only showing a correlation with the birth rate of nulliparous cows.

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