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Adaptive parameters and thermal comfort of postpartum ewes fed on concentrate supplementation in grazing system

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ABSTRACT. Current analysis evaluated adaptive parameters and thermal comfort of postpartum ewes fed on concentrate supplementation in grazing system. Thirty lactating pluriparous sheep, 16 Santa Inês (SI) and 14 Morada Nova (MN) were used. Physiological parameters such as respiratory rate (RR), heart rate (HR) and rectal temperature (RT) were measured, in that order, with the animals at rest in the morning (6:00-7:00 am) and in the afternoon (1:00-2:00 pm), respectively, every seven days, with 10 samples. A significant effect ($p < 0.05$) for RR and HR was reported in the strain. Similar behavior was reported for RR between the breeds where MN sheep had high adaptability. Supplementation levels of 0.5 and 1.5% influenced ($p < 0.05$) RR which was stronger in the sheep that received the highest supplementation level, possibly due to calorie increase in the diet. However, HR and RT parameters did not differ within the breed due to supplementation. HR was higher between the breeds for SI sheep at 0.5%. Results show that concentrated supplementation affected the respiratory rate of ewes in the postpartum period, with higher calorie increment at 1.5% level and superiority for Santa Inês ewes. Greater adaptability of Morada Nova sheep has been indicated when fed on concentrated diet in grazing system.

Keywords: environmental factors, heat stress, nutrition, thermoregulation.

Parâmetros adaptativos e conforto térmico de ovelhas deslanadas no pós-parto submetidas à suplementação concentrada em sistema de pastejo

RESUMO. Objetivou-se avaliar os parâmetros adaptativos e o conforto térmico de ovelhas deslanadas no pós-parto submetidas à suplementação concentrada em sistema de pastejo. Foram utilizadas 30 ovelhas pluríparas em lactação, sendo 16 da raça Santa Inês e 14 da raça Morada Nova. Os parâmetros fisiológicos, frequência cardíaca (FC), frequência respiratória (FR) e temperatura retal (TR) foram aferidos nessa ordem com os animais em repouso nos períodos da manhã e da tarde, de 6:00-7:00 e 13:00-14:00, respectivamente, a cada sete dias, totalizando dez coletas. Houve efeito de turno ($p < 0,05$) para FR e FC dentro de raça. Comportamento semelhante foi observado para FR entre raças, em que as ovelhas Morada Nova apresentaram maior adaptabilidade. Os níveis de suplementação de 0,5 e 1,5% exerceram influência ($p < 0,05$) sobre a FR com superioridade para as ovelhas que receberam maior nível de suplementação, possivelmente pelo incremento calórico na dieta. No entanto, os parâmetros FC e TR não diferiram dentro de raça em função da suplementação, sendo que entre raças a FC foi superior para ovelhas SI a 0,5%. Conclui-se que a suplementação concentrada exerceu influência sobre frequência respiratória das ovelhas deslanadas no pós-parto, com maior incremento calórico para o nível de 1,5% e superioridade para as ovelhas Santa Inês, indicando maior adaptabilidade das ovelhas Morada Nova quando submetidas à dieta concentrada em sistema de pastejo.

Palavras-chave: fatores ambientais, estresse calórico, nutrição, termorregulação.

Introduction

The cattle industry, especially the raising of small ruminants, is extremely important to the economy of the semi-arid region of northeastern Brazil. Sheep production stands out as an asset for the social and economic development of this region, especially due to the degree of the species´s adaptability to the ecologica conditions of the area. Maximum production efficiency is achieved when the animals are under conditions of thermal comfort in which the triggering of thermoregulatory mechanisms is not required (SOUZA et al., 2005).

Among the available genetic resources, the authors would like to enhance the potential use of wool-less and/or native sheep breeds. One presumes that centuries of natural selection promoted high adaptive rates vis-à-vis the semi-arid region, with an

expectation of greater efficiency in animal production (GOMES et al., 2008).

In tropical regions, during most of the year, air temperature and other environmental parameters may cause stress on the animals which, using their thermoregulatory mechanisms, seek to adjust themselves by mainly increasing heat dissipation through skin and respiratory thermolysis (SILVA, 2000). The environment´s thermal limits, established as comforting or stressful, depend on the region and the animal types / breeds used in the farm´s production system (PERISSINOTTO et al., 2009). The animals´ physiological parameters are affected by the time of day, with maximization in the afternoon, which may interfere on the genetic potential of the animals (SILVA et al., 2012).

Coupled to adverse environmental factors which cause thermal stress on animals, food intake also influences heat production in ruminants and the quantity and quality of food interfere with endogenous heat generation, leading to increased physiological parameters (BACCARI JÚNIOR, 2001). However, feed intake by animals is controlled by three major physiological mechanisms: volume intake in the digestive tract, energy density of nutrients in the blood and heat stress (BRIDGES et al., 1992).

Current assay evaluates the adaptive parameters and thermal comfort of postpartum ewes fed on concentrate supplementation in grazing system.

Material and methods

The experiment was conducted at the Small Ruminants Research Unit at the Professora Cinobelina Elvas Campus of the Federal University of Piauí, Vale da Gurguéia region, in Bom Jesus, Piauí State, Brazil. The municipality lies at 9º 4' 28" S and 44º 21' 31" W, altitude of 277 meters, approximately 635 km distant from the capital city Teresina, with a semiarid climate or Bsh, according to Köppen, and annual average rainfall 900 mm, with maximum and minimum temperatures at 36ºC and 18ºC respectively. The rainy season extends from November to May (AGUIAR, 2004).

Thirty lactating pluriparous sheep, 16 Santa Inês and 14 Morada Nova, were used, with an average weight 52.6 kg and 31.3 kg, respectively. During the experimental period the sheep grazed from 7:00 am to 4:30 pm in paddocks formed by andropogon pasture grass (*Andropogon gayanus*). They were collected in the late afternoon and allocated to individual pens where they received concentrate supplementation (Table 1) according to their weight (0.5% and 1.5% of body weight (BW), which was adjusted weekly.

Table 1. Chemical composition of experimental ingredients, concentrate supplement and Andropogon (*Andropogon gayanus*).

Ingredients	Chemical composition (% DM)							
	DM	CP	EE	TDN	NDF	ADF	Ca	P
Corn meal	87.19	9.98	5.19	67.50	24.55	5.87	0.05	0.49
Soybean meal	88.48	48.76	1.75	80.73	15.37	9.64	0.33	0.57
Mineral mixture[1]	97.91	-	-	-	-	-	18.00	13.00
Supplement	88.04	19.17	4.06	67.43	21,02	6,51	0.90	1.13
Andropogon	27.45	7.50	2.02	53.56	74.70	41.97	0.33	0.11

DM = Dry matter; PB = Crude protein; EE = Ether extract; TDN = Total digestible nutrients; Ca = Calcium; p = Phosphorus. [1]Mineral mixture: 1,600 mg zinc, 600 mg copper, 1,500 mg manganese, 1,100 mg iron, 10 mg cobalt, 27 mg iodine and 22 mg selenium. q.s.p. 1,000 g.

Treatments were formulated on the percentage of concentrate supplementation according to the recommendations by NRC (2007) for breeding animals.

Physiological parameters such as respiratory rate (RR), heart rate (HR) and rectal temperature (RT) were measured, in that order, with the animals at rest in the morning (6:00-7:00 am) and afternoon (1:00-2:00 pm), respectively, every seven days. A total of 10 samples was provided. In the case of animals on pasture, they were ushered into a smaller paddock to facilitate the collection of data, thus performing the least-jerky movements that could leave them stressed by changing these parameters.

RR was measured in breaths per minute through direct observation of the movements of left flank; HR was measured in beats per minute with a stethoscope placed between the third and fourth left inter-rib space; RT was registered with a clinical thermometer inserted directly into the rectum of the animals until the firing of the sounder.

Environmental variables such as temperature (T) and relative humidity (RH) were measured with a thermo-hygrometer and temperature of globe-thermometer (thermometer Iconterm® 0-100°C inserted into a black globe 150 mm diameter), at 55 cm deep into the soil close to the animals. BGTH (black globe temperature and humidity) was used for the equation proposed by Buffington et al. (1977), in which BGTH = 0.72 (WBT + BGT) + 40.6 (where: WBT- Wet bulb temperature in °C; BGT- black globe temperature in °C).

The experimental design was completely randomized; split-plot (two levels of supplementation, 0.5 and 1.5% of body weight, two shifts and two strains), with ten replications, repeated in time, with SAS (2003) software, and comparing averages for test F.

Results and discussion

Averages of environmental variables during the experimental period (Table 2) indicate that T was higher in the afternoon. Silva et al. (2012) reported that superiority was due to the high solar radiation at this time of day.

Table 2. Overall averages of climatic variables, index globe temperature and humidity (BGTH) in the different shifts (morning and afternoon) in the Vale de Gurguéia during the experimental period.

Turns	Climatic variables			
	T (ºC)	RH (%)	BGT (ºC)	BGTH
Morning (6:00-7:00 am)	24.26 ± 1.73[b]	78.08 ± 8.71[a]	26.50 ± 3.86[b]	73.50 ± 3.89[b]
Afternoon (1:00-2:00 pm)	35.68 ± 1.66[a]	41.08 ± 6.04[b]	36.91 ± 247[a]	84.68 ± 2.54[a]

*Averages followed by the same letters in the lines do not differ among themselves by test F at 5% probability.

The thermal comfort zone for sheep lies between 20 and 30°C (BAÊTA; SOUSA, 2010) which may be verified during the morning. However, in the afternoon, the conditions imposed by daily variation of environmental parameters in the Gurguéia region were crucial to trigger situations of thermal stress in the animals, as Table 2 demonstrates, with the need for the activation of thermoregulatory mechanisms, mainly respiratory. In optimum temperatures for sheep, 20% of heat loss occurs through breathing. On the other hand, above 35°C, total heat loss via respiration reaches 60% of total heat lost (SOUSA JÚNIOR et al., 2008).

In the case of RH, it may be observed that there was a significant difference ($p < 0.05$) between shifts, with the critical limit of the comfort zone occurring in the afternoon (Table 2), or rather, between 50 and 70%, according to Baêta and Sousa (2010). Relative humidity greatly affects the mechanisms of evaporative heat dissipation and becomes more pronounced when the temperature tends to reach the critical point of discomfort, or rather, outside the thermal neutral zone, as reported for sheep studied in the afternoon. The mechanisms of heat dissipation through the skin and respiratory tract fail in high humidity conditions, causing an increase in stressful conditions and, as a result, deficient animal performance (MEDEIROS et al., 2008). Relative air humidity is directly and inversely related to the temperature, that is, when there is an increase in air temperature, a decrease in RH occurs (SILVA et al., 2012).

The same occurs in the case of the other variables. BGT rose during the day and differed significantly ($p < 0.05$) between shifts, registering 26.50°C during the morning and 36.91°C in the afternoon. Similar results were obtained by Silva et al. (2013) in their assays with sheep in the micro Upper Middle Gurguéia. They reported daily average of 28.53 and 32.06°C for morning and afternoon, respectively.

Globe temperature and humidity (BGTH) rates demonstrate that the highest rates are in the afternoon, featuring an 11.18°C range. According to Souza et al. (2002), BGTH rates at 74 define a comfort situation; 74 - 78 indicates alert conditions; 79 - 84 indicates danger; above 84 the emergency zone is triggered. The latter characterizes the environment with emergency needs and deploys facilities to change this situation. In other words, animal comfort should be provided so that they may express their full productive potential.

There was significant effect ($p < 0.05$) for respiratory and heart rates in the different strains (Table 3), or rather, there was no influence of the period of the day on the physiological responses between Morada Nova sheep and between Santa Inês ewes, with superiority for the afternoon shift for the two strains.

Table 3. Values of physiological responses of postpartum ewes submitted to concentrate supplementation in grazing system in different shifts of the day.

Turns	Physiological variables					
	Respiratory rate (breaths min.$^{-1}$)		Heart rate (beats min.$^{-1}$)		Rectal temperature (°C)	
	MN	SI	MN	SI	MN	SI
Morning	32.19±3.9[bA]	45.65±4.4[bB]	87.63±2.5[bA]	92.49±3.3[bA]	37.63±0.0[Aa]	38.17±0.0[aA]
Afternoon	47.05±3.9[aA]	64.13±4.4[aB]	99.71±2.5[aA]	102.86±3.3[aA]	38.62±0.0[Aa]	38.78±0.0[aA]

*Means followed by the same uppercase and lowercase lines in columns do not differ by test F at 5% probability.

A similar behavior was reported between strains for RR, where the Morada Nova sheep showed greater adaptability to tropical climate in Gurguéia Valley, when subjected to a concentrated food supplement, confirming the higher heat increment provided by the diet. The afternoon is characterized by higher solar radiation when sheep require the employment of more intensively mechanisms for heat dissipation to maintain homeothermy (BAÊTA; SOUSA, 2010). This fact may be affected by the concentrate supplementation fed to sheep, with values characterizing thermal stress in the emergency zone, according to Souza et al. (2002).

HR is influenced by day shift, with values above the reference rates given by Reece (1996) in the two rounds, and with a higher beat frequency in the afternoon, probably due to rise in thermal environmental parameters and with an increase in animal discomfort.

Sheep´s RT was not affected by shifts and maintained itself within the normal range for the

species, according to Silva (2000), or rather, 38.9 and 40.5ºC. McDowell et al. (1976) mentions that a 1°C increase in TR is enough to reduce performance in most species of domestic animals. RT increase is equivalent to the body´s heat accumulation caused by the heat from the environment coupled to the internal generation of heat during the day and the inability of thermoregulatory mechanisms to dissipate excess (BAÊTA; SOUSA, 2010).

Weight-based supplementation levels at 0.5 and 1.5% exerted a stronger influence ($p < 0.05$) on RR in sheep with the highest supplementation level (Table 4). This fact was possibly due to increased calorie diet caused by the elevation of these parameters to dissipate the heat produced endogenously and, consequently, to maintain homeothermy (GOMES et al., 2008).

Table 4. Overall averages of physiological responses of postpartum sheep submitted to concentrate supplementation in grazing system

Treatments	Physiological variables					
	Respiratory rate (breaths min.$^{-1}$)		Heart rate (beats min.$^{-1}$)		Rectal temperature (°C)	
	MN	SI	MN	SI	MN	SI
1 (0.5% PV)	33.8±3.8^{bA}	46.6±3.5^{bB}	91.6±2.3^{aA}	97.4±2.5^{aB}	38.0±0.0^{aA}	38.3±0.0^{aA}
2 (1.5% PV)	45.3±5.0^{aA}	63.1±7.2^{aB}	95.6±3.7^{aA}	97.9±5.7^{aA}	38.2±0.0^{aA}	38.5±0.0^{aA}

*Means followed by the same uppercase and lowercase lines in columns do not differ by test F at 5% probability.

The influence of protein and energy supplementation on heat increment and hence the physiological parameters was also verified by Neiva et al. (2004). The above authors reported that among sheep fed on different levels of dietary protein, an increased respiratory rate was observed in animals fed on higher levels of supplementation. On the other hand, Silva et al. (2006) detected that the different levels of dietary protein and lipids in crossbreed goats were not associated with any differences between RT and RR physiological parameters. RR is an important parameter to quantify the severity of heat stress: stress is considered low when the frequency is 40-60; medium to high stress and high respectively at 60-80 and 80-120 mov. min.$^{-1}$. Stress is classified as severe for sheep above 200 mov. min.$^{-1}$ (SILANIKOVE, 2000).

Results show that Morada Nova sheep have a greater adaptability than that of Santa Inês ewes when subjected to a concentrated food supplementation in grazing system during lactation. It is noteworthy that even Santa Inês sheep subjected to a 1.5% level of body weight showed immediate physiological responses that characterized medium to high stress, possibly in an attempt to eliminate excess heat, as may be observed by RT´s normal patterns.

When evaluating HR, it has been reported that the sheep showed the same pattern of beats per minute, with no statistically significant effect ($p > 0.05$) between levels of dietary supplementation. However, when the effects of strains are compared, Santa Inês ewes exhibited higher rates and indicated greater use of thermoregulatory mechanisms. The pattern of normal beats for ovine species is between 60 and 80 beats per minute (REECE, 1996).

Similar behavior was observed for the sheep´s rectal temperature in the period. According to Kabunga (1992), rectal temperature obtained in the morning hours undergoes distinct effect from environmental variables when compared to that obtained in the afternoon. The above shows there is a delayed effect of climatic variables in RT and immediate effects. These results differ from those by Neiva et al. (2004), where the animals fed on a diet containing high concentrate diet registered significantly higher rectal temperature ($p < 0.05$), confirming diet-caused high heat increment.

These results show good adaptability of the strains under analysis, especially with regard to Morada Nova sheep and indicate that heat removal mechanism through the respiratory route was effective in maintaining normal RT standards.

Conclusion

Concentrate supplementation affected respiratory rate of ewes in the postpartum period, with higher heat increment at 1.5% level and revealed the superiority of Santa Inês ewes. A greater adaptability of Morada Nova sheep may be enhanced when they were subjected to concentrated diet in grazing system.

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