METABOLIC PARAMETERS OF DAIRY GOATS SUBMITTED TO ARTIFICIAL BIOCLIMATIC CONDITIONS SIMILAR TO THOSE OF THE EASTERN AMAZON REGION

PARÂMETROS METABÓLICOS DE CABRAS LEITEIRAS SUBMETIDAS A CONDIÇÕES BIOCLIMÁTICAS ARTIFICIAIS SEMELHANTES À REGIÃO AMAZÔNICA ORIENTAL

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SUMMARY:

This work deals with the adaptability of Alpine and Saanen female goats submitted to artificial bioclimatic conditions similar to those of the the Eastern Amazon Region, when compared to female goats raised under normal typical bioclimatic conditions of regions where they demonstrate seasonality. There was no variation in the average values for corporal weight and body condition score as a function of time; however, during the experimental period, there was a difference in the weight of the animals between groups (50.5 and 41.5 kg, for groups 1 and 2, respectively). During the experimental period, a difference was observed ($p<0.05$) for the studied physiological parameters between the morning and the afternoon, being the afternoon values always higher than the ones in the morning. With regard to triiodotironine, tiroxin and cortisol concentrations behavior as a function of the days, in the different groups and adaptation and experimental periods, no difference was registered between the obtained values during the experimental period ($p>0.05$). According to the results, the animals showed good adaptability to the bioclimatic conditions imposed, since they presented a reduction in metabolic and physiological parameters with time, indicating that female goats can be raised under artificial bioclimatic conditions, without modifying the related physiological standards.

Keywords: Adaptability, bioclimatology, goats

RESUMO:

Este trabalho estudou a adaptabilidade de cabras das raças Alpina e Saanen submetidas a condições bioclimáticas artificiais semelhantes à Região Amazônica Oriental, quando comparadas com cabras criadas em condições bioclimáticas normais típicas de regiões onde as mesmas demonstram comportamento poliéstrico estacional. Não houve variação nos valores médios para os parâmetros de peso corporal e escore de condição corporal (ECC) em função do tempo, no entanto durante a fase experimental houve diferença entre grupos no peso dos animais (50,5 e 41,5 kg, para os grupos 1 e 2, respectivamente). Durante a fase experimental, observou-se diferença ($p<0,05$) para os

parâmetros fisiológicos estudados entre os turnos da manhã e tarde, sendo os valores da tarde sempre superiores aos da manhã. Com relação ao comportamento das concentrações de triiodotironina, tiroxina e cortisol em função dos dias, nos diferentes grupos e fases de adaptação e experimental, não se registrou nenhuma diferença nos valores obtidos durante todo o período experimental (p>0,05). Embora o número de animais avaliados em condições bioclimáticas semelhantes à Região Amazônica Oriental seja pequeno, os valores médios obtidos para os parâmetros fisiológicos, ingestão de alimentos e água, metabólicos e hormonais, indicaram que fêmeas caprinas podem ser criadas nas condições bioclimáticas propostas, sem que haja comprometimento nos referidos padrões fisiológicos.
Palavras chave: Adaptabilidade, bioclimatologia, caprinos

INTRODUCTION:

From the bioclimatic point of view, the answers of the animal to the hot environment are related in various ways and, of course, involve the direct effects of temperature, modifying the regulation of the nervous system, water balance, hormonal level, nutritional balance and biochemical balance (Veríssimo et al., 2009).

Although the goats are considered rustic animals, the association between high temperatures and high humidity of the air and solar radiation can cause behavioral and physiological changes such as the increase of the temperature of the skin, the elevation of the rectal temperature, the increase in the respiratory frequency, the decrease in the food intake and the reduction of the production level (Brasil et al., 2000).

Thus, high temperatures associated with high relative humidity and solar radiation are the main stressful climate factors that cause decrease in growth rate, milk production and reproductive failures (Uribe-Velásquez et al., 1998).

Few researches have been directed to prove the not seasonality of goats created next to the Equator line. In this sense, the Eastern Amazon Region has ideal climate characteristics for scientific proof of this fact, as its photoperiod and stable temperatures during the year only swings in monthly rainfall. Thus, the creation of goats in bioclimatic chambers that simulate the bioclimatic conditions of regions close to the Equator line may become a significant advance in national goat breeding, making the production of kids throughout the year possible, through artificial insemination and embryo transfer programs, with the production and cryopreservation of greater quantity of embryos throughout the year.

Therefore, this study aims to compare the main adaptability of goats submitted to artificial bioclimatic conditions similar to the Eastern Amazon Region with goats reared in bioclimatic normal conditions, typical of regions where they have seasonal poliestric behavior.

MATERIAL AND METHODS:

The study was conducted from April to July, and consisted of an adjustment period of 30 days (Phase 1) and an experimental period of 60 days (Phase 2), in a bioclimatic chamber (Group 1) and in intensive conditions (Group 2) in a goat breeding farm located in Viçosa, in the Zona da Mata Region of Minas Gerais State, Brazil, located at 20°45'45" south latitude and 42°52'04" west of Greenwich, with mean altitude of 752 m, annual mean temperature of 20.9°C, annual rainfall index of 1.203 mm and climate of CWA type (dry winter and rainy summer) according to the Köeppen classification.

Eight non-pregnant and non-lactating Alpine and Saanen goat breeds were used, with good body condition, in reproductive age, 1 to 7 years (2 sexually mature heifers and 6 adults), divided into two homogeneous groups of animals. Animals in group 1 (n = 4) were subjected to three different thermal challenges during the adjustment and experimental periods: 1) 8:00 - 12:00 hours, temperature of 30 ºC; 2) 12:00 - 18:00 , temperature of 35 ºC; 3) 18:00 - 8:00, temperature of 26 ºC, with mean relative humidity of 60% during the day and 12 daily hours of light (6:00 - 18:00 hours), thus simulating bioclimatic conditions of the northern region of Brazil (near the Equator line), with ambient temperature and relative humidity of the air monitored daily. Group 2 (n = 4) was kept in individual cages, which had influence of the normal natural climatic variations of the season.

The bioclimatic chamber has 20 m^2 of area and 2.10 m of right foot and the stalls made of galvanized iron with 1.46 m in length, 0.75 m wide and 1.37 m in height. Thus, in regard to the small dimensions of the bioclimatic chamber, only four animals could be raised into its conditions.

The composition of the diet of the animals was based on the need for maintenance, being composed of 16.15% of crude protein (CP) of Tifton hay (*Cynodon* spp.), addicted to 34.91% of wheat bran, 63.13% of grind maize and 1.96% of mineral, which was offered twice a day (morning and late afternoon) with 500 g/day of concentrate, and supplemented with hay and mineral "ad libitum". The water was offered at a fixed value of 6 L/day, so that one could estimate the daily water consumption, beyond the consumption of concentrate.

Every month the animals were weighed individually on a balance and their body condition score (BCS) measured, based on palpation of the lumbar and sternal regions, assigning values on a scale from 0 to 5, and the BCS of the animal being the average between the two points.

The following clinical parameters were evaluated: rectal temperature (RT), rumination behavior (RB), respiratory (RF) and cardiac frequencies (CF), which were measured twice a day, morning and afternoon.

Blood samples of 7 ml were collected in vacutaineer tubes with puncture through the jugular vein, twice a week, always in the afternoon. The samples were immediately centrifuged at 600 G for 10 minutes, to obtain blood serum and the samples stored in polyethylene tubes (ependorff) at –20 ºC until the day of the procedure (hormonal and metabolic dosages).

For the hormonal dosage, the following parameters were evaluated: serum concentrations of triiodothyronine (T3), thyroxine (T4) and cortisol (CORT). The hormone concentrations were measured by the indirect method of chemiluminescent using commercial kits (Access - Beckman Coulter), according to the protocol recommended by the company. The metabolic strengths were measured by spectrophotometry using commercial kits: albumin - ALB (Alizé - Biomérieux), total protein - TP (Alizé - Biomérieux), and total cholesterol (Bioclin - Quibasa Basic Chemical Ltd.), employing the enzymatic method, following the recommendations of the manufacturers.

To analyse the data obtained in the experiment the statistical programme SAEG-9.1 was employed. Descriptive statistics (mean, standard deviation) was used for all variables (hormonal concentration, homeostatic control and metabolic profile). For the variance analysis it was used a completely randomized design. The hormonal and metabolic profiles were evaluated by variance analysis and regression as a function of time within each shift, within and between experimental animals.

The parameters acquired in the homeostatic control were evaluated by variance analysis, to determine the effect of the period of the day (at times established in the experiment). For the characteristics that had significant effect by F test took place by means of comparison tests of Tukey, with probability of error of 5%. The non-parametric analysis (Wilcoxon) was applied to the data which did not meet assumptions of variance analysis by Lilliefors and Cochran and Barttlet tests (normality of the data and homogeneicity of variance).

RESULTS:

The average temperature where the animals were handled in Group 2 were within the thermal comfort zone for goats (20 to 30 °C) recommended by Silva (2000), being only a little lower during the night along the study period (13.3 ºC) and in the morning (18.7 °C) during the experimental phase. However, for the animals of Group 1, the temperature during the night (26 ºC) and morning (30 °C) remained within the zone of thermal comfort, being exceeded only in the afternoon (35 °C) (table 1).

Table 1: Means and standard deviations of the climatic parameters inside and outside the bioclimatic chamber in dairy goats submitted to artificial bioclimatic conditions similar to the Eastern Amazon Region (Group 1), or not (Group 2).

Parameters	Shifts	Group 1		Group 2	
		Adaptation	Experimental	Adaptation	Experimental
Temperature (ºC)	Morning	30.0 ± 0.0^{aAC}	30.0 ± 0.0^{aAC}	20.9 ± 1.7^{aBC}	18.7 ± 1.8^{bBC}
	Afternoon	35.0 ± 0.0^{aAD}	35.0 ± 0.0^{aAD}	23.1 ± 2.7^{aBCE}	21.6 ± 1.7^{bBD}
	Night	26.0 ± 0.0^{aAE}	26.0 ± 0.0^{aAE}	16.1 ± 2.2^{aBDF}	13.3 ± 2.1^{bBE}
Relative humidity (%)	Morning	61.8 ± 2.3^{aAC}	64.2 ± 1.3^{bAC}	72.4 ± 5.9^{aBC}	72.4 ± 7.5^{aBC}
	Afternoon	56.3 ± 3.1^{aADE}	51.9 ± 2.6^{bADE}	62.2 ± 9.8^{aBD}	58.6 ± 7.2^{bBD}
	Night	62.3 ± 2.6^{aACF}	63.7 ± 2.2^{bACF}	89.6 ± 3.3^{aBE}	90.2 ± 2.4^{aBE}
Fotoperiod (hs)	Daily	12.0 ± 0.0^{aA}	12.0 ± 0.0^{aA}	11.3 ± 1.5^{aB}	10.9 ± 0.6^{bB}

^{a,b} = Average values followed by different lower-case letters in the same line in the same group are different between themselves by F Test (p<0.05).

^{A,B} = Average values followed by different upper-case lettersin the same line and between groups are different between themselves by F Test (p<0.05).

^{C,D,E,F}= Mean values of a same parameter followed by upper-case letters in the same column are different between themselves by F Test (p<0.05).

For the animals in Groups 1 and 2 there was no change in the average values of weight and BCS parameters as a function of time (p>0.05). However, there was a difference in weight between groups of animals during the experimental period, being higher in animals kept in the bioclimatic chamber (p<0.05) (table 2).

Table 2: Means and standard deviations in water and ration consumption, weight and body condition score (BCS) in dairy goats submitted to artificial bioclimatic conditions similar to the Eastern Amazon Region (Group 1), or not (Group 2).

Parameters	Group 1		Group 2	
	Adaptation	Experimental	Adaptation	Experimental
Water (mL)	5,519.0 ± 540.3^{aA}	4,386.3 ±	2,524.0 ± 783.2^{aB}	1,663.2 ±

		1154.1^{bA}		977.9^{bB}
Ration (g)*	482.3 ± 61.1^{aA}	499.0 ± 8.3^{bA}	488.7 ± 45.8^{aA}	490.8 ± 4.6^{bB}
Weight (kg)	52.4 ± 6.3^{aA}	50.5 ± 4.2^{aA}	41.4 ± 7.5^{aA}	41.5 ± 5.6^{aB}
BCS (0-5)	2.4 ± 0.1^{aA}	2.2 ± 0.2^{aA}	2.2 ± 0.3^{aA}	2.2 ± 0.3^{aA}

^{a,b} = Average values followed by different lower-case letters in the same line in the same group are different between themselves by F Test (p<0.05).

^{A,B} = Average values followed by different upper-case letters in the same line and between groups are different between themselves by F Test (p<0.05).

* = Non-parametric analysis by Wilcoxon Test (p<0.05).

The average values for the consumption of water were different (p<0.05) both in terms of the group as a function of time, and the animals in Group 1 consumed more than double the water than the animals in Group 2.

Regarding ration consumption, there was a difference between the average values recorded for the groups and during the experimental period (p<0.05), except in the adaptation period, where there was no difference between groups (p>0.05).

During the adaptation period, there was no difference between the average values for the parameters of RF, CF, RT and RB (table 3) for animals in Group 1 in both shifts of measurement as a function of time (p>0.05), except CF in the morning, which showed an increase as a function of time (p<0.05). The animals in Group 2 showed no difference between the average values of RT in both shifts of measurement and for the values of RF in the morning as a function of time (p>0.05). However, the values of CF and RB in both shifts, and RF in the afternoon showed differences as a function of time (p<0.05).

Table 3: Means and standard deviations of respiratory (RF) and cardiac frequencies (CF), rectal temperature (RT) and rumination behavior (RB) in the morning and afternoon in dairy goats submitted to artificial bioclimatic conditions similar to the Eastern Amazon Region (Group 1), or not (Group 2).

Parameters	Shifts	Group 1		Group 2	
		Adaptation	**Experimental**	**Adaptation**	**Experimental**
RF (mov/min)*	Morning	43.4 ± 19.4^{aAC}	34.5 ± 16.6^{bAC}	28.8 ± 12.4^{aBC}	24.3 ± 10.5^{bBC}
	Afternoon	87.4 ± 34.8^{aAD}	72.1 ± 23.1^{bAD}	32.5 ± 13.7^{aBD}	33.3 ± 18.5^{aBD}
CF (beat/min)	Morning	71.9 ± 21.4^{aAC}	60.2 ± 11.6^{bAC}	84.1 ± 20.7^{aBC}	73.1 ± 16.8^{bBC}
	Afternoon	74.2 ± 19.3^{aAC}	66.1 ± 11.8^{bAD}	83.5 ± 17.9^{aBC}	77.5 ± 14.1^{bBD}
RT (ºC)*	Morning	38.6 ± 0.3^{aAC}	38.4 ± 0.3^{aAC}	38.2 ± 0.3^{aBC}	38.1 ± 0.4^{bBC}
	Afternoon	39.2 ± 0.2^{aAD}	39.1 ± 0.2^{bAD}	38.8 ± 0.3^{aBD}	38.6 ± 2.3^{aBD}
RB (mov/5min)	Morning	2.4 ± 1.1^{aAC}	3.0 ± 1.3^{bAC}	3.3 ± 1.6^{aBC}	3.4 ± 1.6^{aBC}
	Afternoon	3.6 ± 1.3^{aAD}	3.7 ± 1.4^{aAD}	3.9 ± 1.8^{aAD}	4.7 ± 1.9^{bBD}

^{a,b} = Average values followed by different lower-case letters in the same line in the same group are different between themselves by F Test ($p<0.05$).

A,B = Average values followed by different upper-case lettersin the same line and between groups are different between themselves by F Test ($p<0.05$).

C,D,E,F = Mean values of a same parameter followed by upper-case letters in the same column are different between themselves by F Test ($p<0.05$).

* = Non-parametric analysis by Wilcoxon Test ($p<0.05$).

In the experimental period there was no change in behavior of the average values for the parameters of RT in both shifts, of RB in the morning, and CF and RF in the afternoon for animals in group 1 ($p>0.05$). However, the RF and the CF in the morning, and RB in the afternoon, showed a difference in behavior as a function of experimental time ($p<0.05$). The animals in Group 2 showed no difference between the average values for the parameters of RF and RT in the afternoon ($p>0.05$). The values of CF and RB showed changes in both shifts, and the values of RF and RT had only changes by the morning shift as a function of the experimental time ($p<0.05$).

With regard to the behavior of the parameters of cholesterol, ALB, and TP, depending on the day, in different phases and groups, no difference was registered ($p>0.05$) in average values throughout the experimental period (table 4).

Table 4: Means and standard deviations of the serum cholesterol, total protein (TP) and albumin (ALB) in dairy goats submitted to artificial bioclimatic conditions similar to the Eastern Amazon Region (Group 1), or not (Group 2).

Parameters	**Group 1**		**Group 2**	
	Adaptation	**Experimental**	**Adaptation**	**Experimental**
Cholesterol (mg/dL)	81.8 ± 20.6^{aA}	95.6 ± 27.8^{bA}	90.1 ± 16.4^{aA}	107.1 ± 24.1^{bB}
TP (g/dL)	8.6 ± 0.9^{aA}	9.1 ± 1.6^{aA}	7.8 ± 0.6^{aB}	8.1 ± 1.4^{aB}
ALB (g/dL)	3.0 ± 0.3^{aA}	3.2 ± 0.4^{bA}	3.2 ± 0.3^{aB}	3.4 ± 0.3^{bB}

a,b = Average values followed by different lower-case letters in the same line in the same group are different between themselves by F Test ($p<0.05$).

A,B = Average values followed by different upper-case lettersin the same line and between groups are different between themselves by F Test ($p<0.05$).

The values observed in this study where: TP of 9.1 and 8.1 g/dL and ALB of 3.2 and 3.4 g/dl, for groups 1 and 2, respectively (table 4). Additionally, there were lower average values ($p<0.05$) for the concentration of cholesterol and ALB in the animals subjected to heat stress (Group 1), than the values recorded for the non-stressed animals (Group 2). However, the concentration of TP proved to be greater for the animals in Group 1 (table 4, $p<0.05$).

With regard to the behavior of T3, T4 and cortisol as a function of the days in different groups and periods (adaptation and experimental), there was no difference registered in the values obtained during the adaptation period ($p>0.05$). During experimental period (table 5) there was no difference between the groups ($p>0.05$), except the values of cortisol and T4 which were, in absolute numbers, a little higher for animals in Group 2, which may have reflected the greatest cholesterol concentration observed in animals of this group (table 4).

Table 5: Means and standard deviations fo serum triiodothyronine (T3), thiroxine (T4) and cortisol concentrations during experimental period (phase 2) in dairy goats submitted to artificial bioclimatic conditions similar to the Eastern Amazon Region (Group 1), or not (Group 2).

Levies	**Days of phase 2**	**T3 (ng/mL)**		**T4 (ng/mL)**		**Cortisol (ng/mL)**	
		Group 1	**Group 2**	**Group 1**	**Group 2**	**Group 1**	**Group 2**
9	34	*2.3 ± 3.8[a]	0.9 ± 0.5[a]	61.3 ± 7.1[a]	79.6 ± 12.7[b]	9.6 ± 4.6[a]	7.4 ± 2.6[a]
10	37	*2.3 ± 3.8[a]	0.9 ± 0.4[a]	54.0 ± 28.3[a]	85.6 ± 14.1[a]	9.3 ± 1.7[a]	10.0 ± 1.7[a]
11	41	*2.6 ± 3.6[a]	0.6 ± 0.3[a]	61.3 ± 20.9[a]	72.6 ± 2.6[a]	8.5 ± 1.5[a]	12.3 ± 9.8[a]
12	44	0.9 ± 1.0[a]	0.9 ± 0.6[a]	60.3 ± 12.9[a]	83.4 ± 13.8[b]	6.7 ± 4.3[a]	20.0 ± 27.6[a]
13	48	0.4 ± 0.1[a]	0.6 ± 0.3[a]	44.7 ± 29.9[a]	74.0 ± 14.6[a]	5.5 ± 3.2[a]	12.2 ± 14.5[a]
14	51	0.4 ± 0.1[a]	0.6 ± 0.4[a]	63.4 ± 15.5[a]	64.0 ±14.2[a]	4.7 ± 1.6[a]	15.5 ± 12.2[a]
15	55	0.7 ± 0.4[a]	0.6 ± 0.4[a]	60.9 ± 6.2[a]	71.6 ± 12.7[a]	*4.1 ± 2.0[a]	18.3 ± 25.1[a]
16	58	0.6 ± 0.4[a]	0.6 ± 0.2[a]	59.6 ± 16.5[a]	77.4 ± 19.8[a]	*4.9 ± 3.2[a]	20.0 ± 30.0[a]
17	62	0.6 ± 0.3[a]	0.5 ± 0.2[a]	65.0 ± 18.4[a]	75.2 ± 27.2[a]	*7.6 ± 1.5[a]	22.3 ± 23.0[a]
18	65	0.8 ± 0.3[a]	0.7 ± 0.3[a]	57.5 ± 20.6[a]	82.7 ± 15.2[a]	*6.9 ± 4.9[a]	18.2 ± 18.3[a]
19	69	0.7 ± 0.2[a]	0.8 ± 0.5[a]	52.7 ± 18.9[a]	72.3 ± 12.0[a]	4.4 ± 2.6[a]	20.4 ± 15.4[a]
20	72	0.8 ± 0.4[a]	0.7 ± 0.5[a]	62.1 ± 24.4[a]	60.7 ±5.3[a]	5.3 ± 3.5[a]	14.7 ± 16.8[a]
21	76	0.5 ± 0.2[a]	0.8 ± 0.2[a]	60.1 ± 17.5[a]	86.5 ± 26.0[a]	6.7 ± 5.0[a]	10.1 ± 5.9[a]
22	79	1.0 ± 0.4[a]	0.8 ± 0.2[a]	52.2 ± 21.9[a]	81.1 ± 7.6[b]	*5.7 ± 1.7[a]	14.8 ± 13.2[a]
23	83	0.7 ± 0.6[a]	0.7 ± 0.2[a]	71.2 ± 21.9[a]	84.0 ± 14.5[a]	8.4 ± 2.4[a]	9.2 ± 3.5[a]
24	86	0.4 ± 0.1[a]	0.6 ± 0.2[a]	64.6 ± 13.5[a]	81.7 ± 10.0[a]	4.6 ± 3.3[a]	14.4 ± 20.1[a]

25	90	0.6 ± 0.3[a]	0.6 ± 0.1[a]	56.5 ± 32.8[a]	77.5 ± 13.1[a]	6.7 ± 5.8[a]	9.1 ± 6.0[a]

* = Non-parametric analysis by Wilcoxon Test ($p<0.05$).

[a,b] = Average values followed by different lower-case letters in the same line in the same group are different between themselves by F Test ($p<0.05$).

DISCUSSION:

The higher water consumption of the animals in Group 1 reflects the need for cooling the body by conduction and restore the water evaporated by the respiratory tract and skin. Marai et al. (2006), working with sheeps, assert that the consumption of water is equivalent to 9 to 11% of body weight during the winter, and 19 to 25% during the summer, in agreement with the results observed in this study (table 2), except for ration consumption, which showed no change for animals submitted to heat stress.

Brasil et al. (2000) found that the stressed goats had weight loss, reduction of dry matter consumption and duplication of water consumption, and the stressed animals consumed 62.5% less hay during the daytime, and at night this difference fell to 16%, noting a partial compensatory effect in food intake, which was not sufficient to reach the consumption of non-stressed goats.

In relation to weight and BCS of the animals (table 2), a mild loss of body weight of the animals in both groups at the adaptation period, although not significant, is mainly due to the stress which all animals were submitted due to the environmental change (placing in individual cages), but that was restored and maintained constant throughout the experimental period. These results are consistent with those observed by Dixon et al. (1999), who observed no differences between the gain of weight due to the effect of the environment.

In this study, the RT raised in animals of both groups in the afternoon (39.1 and 38.6 ºC, for groups 1 and 2, respectively) when compared to the morning values (38.4 and 38.1 ºC for groups 1 and 2, respectively) ($p<0.05$) (table 3), although the animals in group 1 had been submitted in the afternoon to a temperature of 5 °C above the temperature of thermal comfort. Brasil et al. (2000) had already observed hyperthermia (40.7 °C) in animals under heat stress during the afternoon and RT slightly lower (39.1 °C) during the morning, but with values very high when compared to the results of this study.

An important fact to be emphasized is that the studies cited by several authors use a single high temperature within bioclimatic chambers for a short period of days or for only a few hours during the day, while this study worked with a variation of three temperatures throughout the day and a long period of time (3 months), simulating natural bioclimatic conditions of Eastern Amazon Region.

The impact of heat on the physiological variables results in an increase of 3.3% in the RT and 194% in the RF, with modifications from 38.6 to 39.9 °C, and from 32 to 94 mov/min, respectively (Souza et al., 2005). In this study, this caloric impact resulted in an increase of 1.8% in RT and 109% in RF for animals in Group 1, while the animals in Group 2 had a slightly smaller increase of 1.4% in RT and 36.6% in the RF (table 3). Silva & Starling (2003) says that the most part of body heat is lost through RF. According, in a study conducted by Marai et al. (2006), the animals lost about 20% of body heat through the RF in thermoneutral environments, while in environments under heat stress that loss increased to 60%.

Shinde et al. (2002) recorded an increase of CF ranging from 57.8 to 90.6 beats/min in the morning and afternoon, respectively, in animals subjected to heat stress. In part, this occurs to increase the circulation to the skin, improving the efficiency of evaporation through skin, and can still be explained to increase the blood supply to the respiratory muscles, to supply the increased energy required. But Souza et al. (2005) recorded no differences with the CF for native and exotic animals reared in the State of Paraíba (Brazil), but with much higher average (128.0 and 125.2 beats/min in the morning and afternoon, respectively) than that recorded in this study, which was 60.2 and 73.1 beats/min in the morning, and 66.1 and 77.5 beats/min in the afternoon, for groups 1 and 2, respectively, where there was a difference between shifts ($p<0.05$).

The CF for the animals in Group 2 remained always higher than that for animals in Group 1 (table 3), probably due to a greater quantity of RB in the animals in Group 2 in relation to the ones in Group 1 in both shifts (3.4 and 3.0 mov/5min for animals in groups 2 and 1, respectively, in the morning and 4.7 and 3.7 mov/5min for animals in groups 2 and 1, respectively, in the afternoon), in addition to stress that the animals in Group 2 were submitted by management, under influence of external factors, which the animals in Group 1 did not have, since they were isolated inside the bioclimatic chamber throughout the adaptation and experimental periods.

Hirayama et al. (2004) recorded averages of RB of 4.9 mov/5 min and 5.7 mov/5 min for the stressed and non-stressed groups, respectively, being somewhat higher than those recorded in this study, which were 3.0 and 3.4, and 3.7 and 4.7 for animals in groups 1 and 2 in the morning and afternoon, respectively, with differences being observed between the groups in both shifts, in the measurement of RB ($p<0.05$). This decay is probably due in part to the mechanism of control of thermogenesis, in order to maintain body homeostasis.

It is important to underline that the parameters studied during the experimental period showed a decay when compared to the adaptation period, except for RB, which presented no difference during the hottest hours (afternoon) ($p>0.05$), being different only for the morning, where it had just raised during the experimental period ($p<0.05$). This fact highlights the adaptation ability of these animals to the hot weather to which they have been submitted.

In this study, despite the high temperature in the afternoon, the excess of heat stored during the day was dispelled during the night, due to variations of temperatures to which Group 1 was subjected during the day, proving the adaptability of these animals to the temperatures to which they were subjected. However, the RF for animals in group 1 was above the physiological for the species, demonstrating that the high temperature, especially during the afternoon, interfered, enabling the thermoregulatory system, promoting greater loss of heat, through evaporation by breathing.

Reference values of blood concentrations of cholesterol in goats have been reported by several researchers, with minimum and maximum limits ranging, respectively, from 80 to 130 mg/dL (Kaneko et al., 1997). Uribe-Velásquez et al. (1998) recorded values of 86.9 ± 12.1 ng/mL for animals under heat stress, and 87.8 ± 11.7 mg/dL, for animals under thermoneutral conditions, with no difference between them. In this study, the animals in Group 2 showed average of 107.1 ng/mL, within the limits considered physiological, and different values recorded for the animals in Group 1 (95.6 ng/mL) (table 4; $p<0.05$) being in contradiction with the studies made by Nazifi et al. (2003), which recorded higher values of cholesterol in animals subjected to stress by cold (185 ng/mL) than in thermoneutral conditions (142 ng/mL) and heat stress (146 ng/mL). It is noteworthy that for animals in Group 2, although under natural raising conditions, during the night, it was observed that they were subjected to stress by cold (table 1), hence the high values for cholesterol concentrations when compared to group 1.

The values for TP and ALB (table 4) are according to the reference values of 6.4 to 9.0 g/dl (TP) and 2.7 to 3.9 g/dl (ALB) (Kaneko et al., 1997). Nazifi et al. (2003), in a comparative study of biochemical blood parameters for sheeps subjected to heat stress, observed changes in the values of TP for animals subjected to stress by cold (6.2 g/dL) when compared to animals under thermoneutral conditions (5.5 g/dL) and heat stress (5.7 ng/mL).

According to the reference values of cortisol (5 to 15 ng/mL) described by Kaneko et al. (1997), it can be said that both the animals in Group 1 and those in Group 2 were adapted to the conditions imposed, and although the values for Group 2 were numerically higher than those for Group 1 (table 5), there was no difference between them ($p>0.05$). The slightly higher values recorded in Group 2 may be, probably, the response of some animals in Group 2, which were subjected to external stressful factors due to the management, and the stress induced by cold during the night (table 1), which the animals in Group 1 did not have, since they were isolated within the bioclimatic chamber throughout the experimental period.

However, unlike the results recorded for the animals of the study in question, several researches have shown that both stresses, cold and heat, influence significantly in cortisol serum concentrations, as can be evidenced by the results of Nazifi et al (2003), which showed changed levels of cortisol in animals under conditions of cold stress (16.6 ng/mL) and heat stress (19.3 ng/mL), when compared to animals in thermoneutral conditions (10.8 ng/mL), but within the acceptable range of Kaneko et al. (1997), and Starling et al. (2005), who studying the seasonal variation of T3, T4 and cortisol in sheeps under tropical environment, recorded the highest average cortisol during the spring and summer, with higher values (15.2 and 15.4 ng/mL) than those recorded during the fall and winter (12.3 and 12.3 ng/mL) ($p<0.05$). During these seasons, the largest average air temperatures and partial steam pressure occur, which could have influenced the blood concentration of cortisol, as the high humidity of the air, together with its high temperature, complicates the process of thermolisis in animals.

Bhattacharyya et al. (1995) observed T3 and T4 concentrations in goats during the winter and summer of 0.9 ± 0.1 and 62.8 ± 0.1 ng/mL, 0.7 ± 0.1 and 57.7 ± 4, 4 ng/mL, respectively, and only different concentrations of T3, agreeing with the results of this study (table 5).

CONCLUSIONS:

Therefore, the animals had acceptable stress patterns in relation to the imposed conditions, with the secretion of cortisol, T3, T4 and cholesterol staying within the limits prescribed for the species;

The animals showed good adaptability to the bioclimatic conditions imposed, since they presented a reduction in metabolic and physiological parameters with time, indicating that female goats can be raised under artificial bioclimatic conditions, without modifying the related physiological standards.

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