Adaptive evaluation of different coat colour of Morada Nova sheep in an equatorial semiarid region

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Abstract: Present paper is aimed to show thermoregulatory responses of locally adapted sheep with different coat colors, in an equatorial semiarid region. There were used four groups according to the coat color: (1) dark red animals, (2) intermediate red, (3) light red, and (4) white coated animals. Animals were measured for rectal temperature (RT), skin surface temperature (ST), respiratory rate (RR), heat loss by respiratory evaporation (RE), heat exchange by convection (HC) and radiation (HR), from 1100 to 1400 hour, after the animals had stayed in a pen exposed to the sun. Results showed that all groups maintained homeothermy. The RR was higher in the animals of groups 1 to 3, which also showed higher values for ST when compared to the white coated animals. Sensible heat exchange mechanisms were not important for heat loss and HR was a significant source of heat gain by animals from the environment. Groups 1, 2 and 3 used RR in a more intense way compared to group 4. It was concluded that Morada Nova sheep has good adaptability to the semiarid environment, regardless of the coat color.

Keywords: adaptation, equatorial semi-arid, homeothermy, naturalized breed, thermoregulatory mechanisms.

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Introduction

Global climate changes have influenced the productivity of most domestic animals, especially those who are sensitive to environments with high temperature and solar radiation levels, features easily found in tropical areas throughout the year (Silva et al., 2010). Thus, it is necessary to characterize the genetic resources and understand all the mechanisms related to the adaptability of these animals to the production system, especially the animals on grazing, directly exposed to the environment conditions (Mariante et al., 2005). In this context, it should be noted the Morada Nova sheep, the only breed locally acclimated to the northeastern Brazil. The main problems affecting the expansion of this breed in the competitive meat production systems are related with the selection criteria, which are primarily focused on racial standards, regardless of characteristics related to productivity and physiological adaptation.

According to the Brazilian Association of Sheep Breeders (ARCO), there are two varieties of Morada Nova sheep, the white and the red. The last one is the most commonly used in the livestock production systems. However, there are several tonalities of the red variety, ranging from light to deep dark red. The red variety breeders usually discard animals with the darker and the lighter colors, a selection criterion without any theoretical basis but that contributes to a significant reduction impact on the genetic variability of Morada Nova population. The white variety is sparsely adopted and there has no more than five herds throughout the national territory, which increases the extinction risks of this valuable genetic resource. The reasons behind those facts is a supposedly low adaptation capability of the white animals to the semiarid environment.

Based upon those issues we developed the present study aiming to evaluate the thermoregulatory responses of Morada Nova sheep of different coat colors. It is expected to provide information that contribute to the selection of thermotolerant animals that present a good performance under the extensive production system in the Caatinga region, making the breed more attractive and assisting their conservation and improvement.

Material and Methods

The experiment was carried out in three commercial herds under the environmental conditions of equatorial semiarid conditions in Morada Nova and Quixeramobim city, State of Ceará, Brazil. There were used 40 Morada Nova ewes in each herd, always the same animals. The data were recorded from April (rainy season) to October (dry season), once a month in each herd, from 1100 to the 1400 hour. The animals remained under direct sunlight for 30 minutes before evaluated.

The animals were divided into four groups, according to its coat color, as follows: Group 1 (dark red animals); Group 2 (animals with intermediate red color); Group 3 (light red animals); Group 4 (white coated animals). Environmental and physiological variables were recorded simultaneously in the same places the animals were. Dry and wet-bulb temperatures (T_A and T_U,°C) were obtained with a ventilated psychrometer, and the partial vapor pressure (Pp, kPa) was calculated according Silva (2008). Black globe temperature (Tg,°C) was taken by a 15 cm diameter copper black globe, positioned in the same place the animals were located. Wind speed was registered with a digital anemometer (W, $m.s^{-1}$). The mean radiant temperature (MRT,°C) of the environment was obtained from T_G, and used to obtain the Radiant Heat Load (RHL, $W.m^{-2}$) according Silva (2008). Rectal temperature (RT, °C) was measured with a digital clinical thermometer inserted into the animal's rectum. The respiratory rate (RR, breaths/minute) was recorded by counting flank movements. Coat surface temperature (TS, °C) was taken using an infrared thermometer (Dt 8550) in three body regions: neck, flank and rump. As for the heat loss by respiratory evaporation (RE; $W.m^{-2}$), there was used the method described by Silva et al. (2002).

The rate of convective heat flow from the coat surface to the surrounding air is given by the equation:

$$HC = \frac{\rho c_p (ST - T_A)}{r_H} \quad W.m^{-2}$$

Where T_A and ST are the air and coat surface temperature, respectively, while r_H (Sm^{-1}) is the boundary layer resistance to convective heat transfer.

$$r_H = \frac{\rho c_p d}{k N_u} \quad s.m^{-1}$$

where d (m) is the characteristic dimension of the body that was estimated as the square root of the body surface area, determined from the body weight P (kg) as $A_S = 0{,}171P^{0.503}$ after Bennett (1973); ρ ($g.m^{-3}$) is the density, c_ρ ($J.g^{-1}.K^{-1}$) the specific heat, and κ ($W.m^{-1}.K^{-1}$) the thermal conductivity of the air (Silva 2008).

The Nusselt number (N_U) was estimated as for a horizontal cylinder by Churchill and Bernstein (1977) equation; Reynolds, Prandtl and Grashof numbers were obtained as given by Silva (2008).
The heat exchange by radiation was estimated by follow equation:

$$HR = \frac{\rho C_P (ST-MRT)}{r_R} \; W.m-^{2}$$

Where ST and MRT are body surface temperature (°K) and mean radiant temperature (°K).

$$r_R = \frac{\rho c_p}{4\varepsilon\sigma Tm^3}$$

Where ε is emissivity thermal radiation of animal surface, ε=0.98. The σ is the Stefan-Boltzmann constant, σ=5,67051x10^{-8} W m^{-2} k^{-1}. The Tm = 0.5 (ST+MRT).

Analyzes of variance were performed by PROC MIXED (SAS) where time as a repeated measure, and was analyzed effect of month, coat color, Radiant Heat Load class and the interaction between coat color and RHL. Logistic regression was used to determine the response of animals with different tonality of coat in shown a normal values for physiological variables for rectal temperature (0= with normal range among 38.3 to 39.9°C and 1= outside normal range) and respiratory rate (0= animals that showed around 40-60 breaths per minute and 1= for animals that the RR were above 60 breaths per minute).

Results and Discussion

All animals maintained homeothermy, and no significant differences were found for RT among the groups within RHL, according to Figure 1. Dark red animals showed the greater variation on RT average within RHL class (38.6 to 39.5°C), which can be a result of an increased heat gain resulting into greater body temperature. The white coated animals showed lower RT variation, and even under almost double RHL they could maintain constant RT. This results may be a good indication of homeothermy. Silanikove (2000) reported that RT and respiratory rate were the main characteristics to be monitored in animals exposed to hot environments. Gebremedhin et al. (2008) describe the RT as the most reliable indicator to measure heat stress.

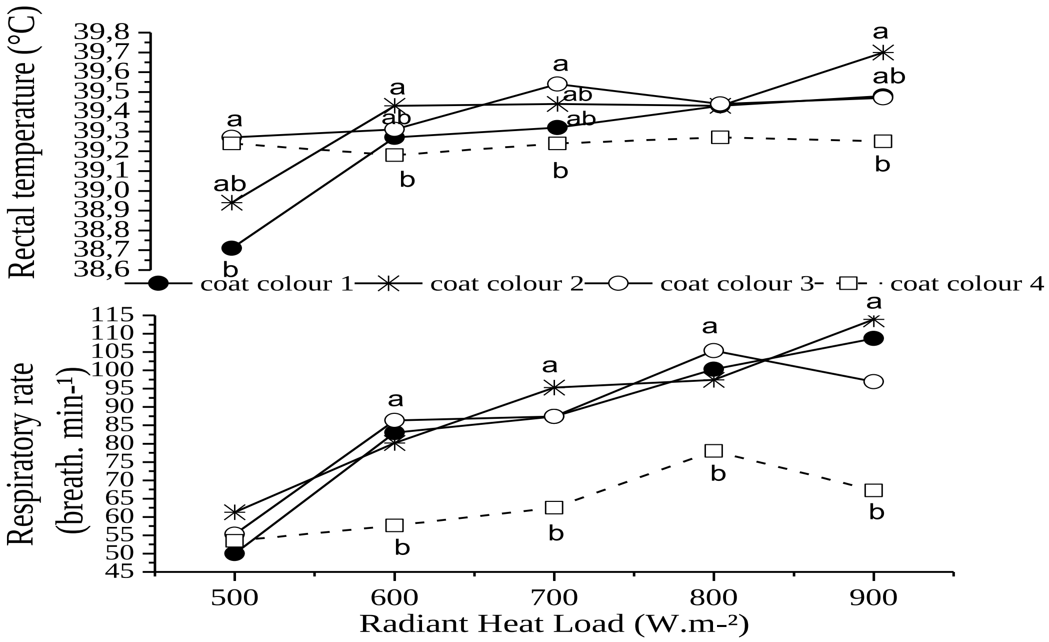

Figure 1. Means of rectal temperature and respiratory rate of Morada Nova sheep in Brazil semiarid region, as function of Radiant Heat Load class of different coat color. Coat color 1 = dark red coat, Coat color 2 = red coat with intermediate tonality, Coat color 3 = light red coat and Coat color 4 = white coated animals totally white

As for the respiratory rate (RR), there was a significant difference among groups according to RHL (Figure 1); in an environment of 500 Wm-² RHL there were no significant differences between groups.

However, in 600 Wm-² RHL class, white coated animals showed the less average RR. Animals with red coat color of different tonalities showed no significant differences in relation to RR, indicating the homogeneity of the red variety for the absorption of radiation and body warming, necessary to activate RR. All groups showed an increase of RR under the highest RHL classes, and this increase was more pronounced in animals with red coat color, regardless of tonality, which showed an increased by 107% RR when RHL changed from 500 to 900 Wm^{-2}. This behavior was not observed in white animals, which even exposed to the same RHL class of the other groups, showed less variation in RR, from 59 to 68 breaths/min, an increase of only 15% over the radiation extremes.

The logistic regression analysis showed that animals with dark red coat triggered more the RR, where 79.74% of the animals presented RR above 60 $breaths.min^{-1}$, while white coat animals triggered less this mechanism and only 52.6% had RR above of this value considered as stressed (Figure 2). Silanikove (2000) reported that this variable can quantify the severity of the stress to which the animals are exposed, in so that the RR up to 60 breaths.min-¹ is considered low stress, and RR above this values is considered medium and high stress. For RT only 17% of the animals of group 1 presented RT above 39.9 ° C and 10% of the white animals showed RT above 39.9°C (Figure 2).

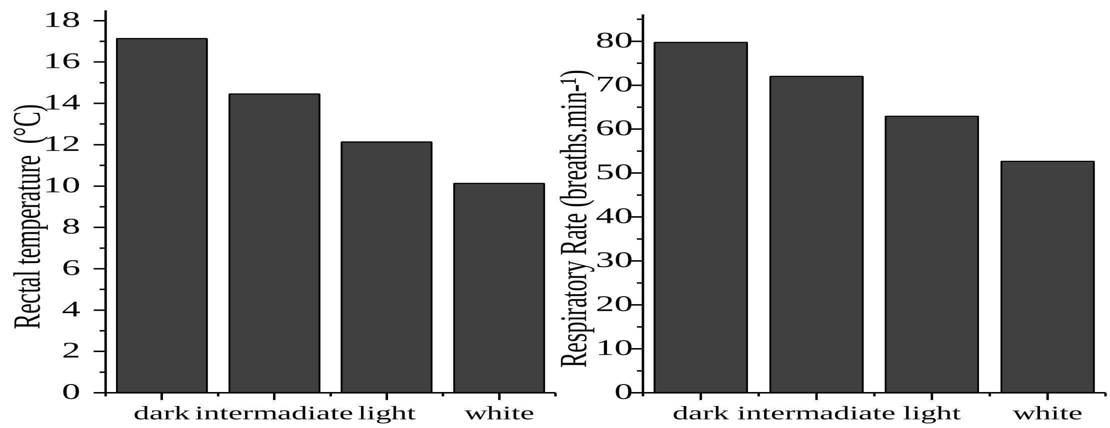

Figure 2. Logistic regression of rectal temperature (RT), respiratory rate (RR), per coat tonality in Morada Nova sheep in an equatorial semiarid region

There was significant difference among animals in relation to coat color, so that animals with red coat color, regardless of tonality, showed high rectal temperature (RT) respiratory rate (RR) and respiratory evaporation (RE), and gained less heat by thermal radiation as well as lost less heat by convection (HC) than white coat animals (Table 1). Present results show that the sensible heat transfers by convection (HC) and by radiation (HR) were not efficient enough to assist the thermal equilibrium by the animal, and may even be a source of heat gain from the environment, as was observed for the thermal radiation. The sensible heat exchange mechanisms depend on a temperature gradient between the body surface and the environment and become ineffective when this temperature difference are very close or does not exist (Silva 2008).

In the present study there were found differences in the RR among the groups, so that the red variety triggered RR as an intense response to heat stress, possibly due to increased body heating; on the other hand, white animals presented low intensity of RR to maintain thermal balance, which may be due to a lower heating of this group of animals. However, all the animal groups could keep homeothermy regardless of mechanism used.

Table 1. Means and standard errors of rectal temperature (RT), respiratory rate (RR), heat loss by respiratory evaporation (RE) evaporation, heat loss by convection (HC) and thermal radiation heat gain (HR) in different coat tonality of Morada Nova sheep in an equatorial region

Efeito	RT (°C)	RR(mpm)	RE (W.m-²)	HC(W.m-²)	HR(W.m-²)
Red Variety					
Dark	39,3^{ab}±0,06	93^{a}±3,3	26,62^{a} ±0,3	7,4^{b}±0,9	228,9^{b}±2,1
Intermadiate	39,4^{a}±0,06	93^{a}±3,1	26,3^{a}±0,2	6,2^{b}±0,8	230,7^{b}±2,0
Light	39,4^{a}±0,05	92^{a}±2,9	26,5^{a}±0,2	7,8^{b}±0,8	229,8^{b}±1,9

White Variety	$39,2^b$±0,005	65^b ±2,8	$27,5^b$±0,2	$11,7^a$±0,8	$252,6^a$±1,9

Nowadays, there is an intense selection system for Morada Nova animals, by considering the main feature the racial pattern, based on criteria such as coat color, ear size and pigmentation of hooves and nasal mirror (ARCO 2016). The result of such methods is the reducing genetic variability within the herds of the breed. Shiotsuki et al. (2016) evaluated criteria of the race selection and realized that the animals are primarily selected based on outdoor characteristics as coat color pigment of the hulls and absence of horns, for example, characteristics that are associated with low weight birth of the animals.

The farmers usually discarded red coat animals with dark and light tonality as well as the white coat ones, they justify that this animals are less adapted to the semiarid conditions. Through the result of this work it is noticed that the animals with dark red or light red coat are not less adapted to a hot environment. White coat animals were also able to maintain thermal balance when exposed to the same levels of solar radiation as the red animals. These results confirm the adaptive ability of Morada Nova, regardless of its color and variety. Finally, it is possible to say that the results of this study can help the Morada Nova breeders to adopt selection and management strategies to improve the performance of the breed, and thus preventing its risk of extinction. This is a more drastic problem, as for the white variety, of which there are recognized three commercial flocks only, which had been proved as important sources of genetic material adapted to hot environmental conditions.

Conclusions

The Morada Nova sheep, regardless of coat color, could keep homeothermy and can be discarded the hypothesis that there are differences in adaptive capacity according to the coat color, so all animals can be used in production systems, a fact that can leave to greater genetic variability of livestock.

White variety represents an excellent locally adapted resource of managed in semiarid region of Brazil and must be preserved and multiplied, since they have good adaptive responses to the environment with high levels of solar radiation.

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