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Assessment of body and scrotal thermoregulation and semen quality of hair sheep rams throughout the year in a tropical environment

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ABSTRACT

The present study was carried out to assess the capacity of Morada Nova (MON) and Santa Inês (SIN) hair sheep breeds to maintain homeothermy and its relation with semen quality in a tropical climate. Sixteen rams (MON = 7 and SIN = 9) were assessed for 12 months. During summer and spring, the Temperature-Humidity Index values surpassed the level indicative of thermal stress, and sweating, respiratory and heart rates increased ($P < .05$). Those responses allowed animals to dissipate heat, maintain rectal temperature in the physiological range and efficiently avoid thermal stress. Scrotal temperatures rose during summer and spring, but, unlike what occurs in wool breeds of sheep, the thermal gradient between poles of testis increased, which shows efficient compensatory scrotal thermoregulation in both breeds herein studied. Semen quality parameters remained within normal ranges. The high correlation observed between rectal and spermatic funicle temperature gradients with sperm membrane integrity ($r = 0.62$; $P < .05$) confirmed the importance of systemic and gonadal thermoregulation for the production of ejaculates with highest possible proportion of viable spermatozoa. Thus, MON and SIN rams can be considered resilient to tropical climate since they efficiently perform the thermolysis to face thermal challenges with no negative impact on semen quality throughout the year. Those adaptability characteristics are highly desirable in the genotypes proposed for use in production systems in tropical environments.

1. Introduction

The need to feed the growing global population requires more intense and efficient agricultural and livestock production worldwide, particularly in the intertropical region (Renaudeau et al., 2012; Scholtz et al., 2013). However, tropical climate is considered restrictive to higher productivity in livestock farming due to the heat stress the animals often experience (Strong et al., 2015). As other production animals (Barros et al., 2015; Bova et al., 2014; Garcia et al., 2011; Kadzere et al., 2002; Lida and Koketsu, 2015), sheep are also subjected to the adverse climatic effects of tropical zone (Marai et al., 2007; Salehian et al., 2015) and must dissipate heat absorbed from the environment, as well as their excessive metabolic heat (Randall et al., 2000). Thus, tropical climate may limit sheep farming due to the constant action of stressful climate elements, which are able to cause thermoregulatory overload even in breeds considered more adapted to those environments (McManus et al., 2015).

When subjected to constantly high environmental temperatures, rams are at higher risk of increases in scrotal temperature and consequent testicular degeneration (Rasooli et al., 2010). That may lead to lower semen quality and cause infertility or subfertility (Garcia, 2013; Marai et al., 2007). In face of that, previous studies report that both absolute temperature in different regions of the testes and the testicular thermal gradient have proved to be interesting indicators of semen quality (Menegassi et al., 2015) and fertility of animals reared on pasture (Lunstra and Coulter, 1997).

One of the strategies to increase ovine fertility in production systems in tropical environments should be based on using rams of more resilient genotypes as breeders. Breeds developed in the tropics, such as Morada Nova and Santa Inês are supposedly more resistant to heat since

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they have been selected in environments where tropical climates prevail. Moreover, they have other desirable attributes such as higher resistance to parasites, high capacity of forage utilization and good carcass yield (Garcia et al., 2010; Rajab et al., 1992; Ribeiro and González-García, 2016).

Hence, knowing the adaptive characteristics to tropical environments may provide a ground for the choice of genotype to be used, either as a basis for animal breeding programs or for the conservation of genetic resources. Thus, the goal of this study was to assess the capacity to maintain homeothermy and its relation with semen quality in Morada Nova and Santa Inês rams subjected to tropical climate conditions throughout the year.

2. Material and methods

2.1. Location and climate characterization

The trial was carried out between January and December 2014 at Embrapa Southeast Livestock in São Carlos, SP, Brazil (21°57‘30“S, 47°50‘36“W, altitude 835 m) and was previously approved by the Experimental Animal Use Ethics Committee (protocol CEUA-CPPSE #2106/2013).

The region has high-altitude tropical (Cwa) climate according to the Köppen–Geiger classification (Kottek et al., 2006) with four well-defined climate seasons: summer (21st December–20th March), fall (21st March–20th June), winter (21st June–22nd September) and spring (23rd September–20th December). Historically, along the year, the mean maximum air temperature ranges from 29.2 to 36.6 °C with peaks of up to 38.0 °C. The mean relative air humidity ranges from 55.3 to 90.5% and the mean annual rainfall is 1361 mm (EMBRAPA, 2015).

2.2. Climate variables

The climate variables of air temperature (AT, °C), relative air humidity (RH, %), rainfall (mm), and overall solar radiation (MJ/m^2) were monitored using an automated meteorological station 400 m away from the facilities where animals were maintained. In order to characterize the 12-month experimental period, the monthly Temperature-Humidity Index (THI) was calculated according to the formula: THI = AT – [(0.31–0.31RH) (AT – 14.4)]. AT is the air temperature (°C) measured with a dry-bulb thermometer and RH is the relative air humidity (%). The THI values obtained indicate: < 22.2 = no thermal stress; 22.2 to < 23.3 = moderate thermal stress; 23.3 to < 25.6 = severe thermal stress; and ≥25.6 = very severe thermal stress (Marai et al., 2007). In addition, the THI was determined at the moment of physiological data collection in order to assess environmental conditions in real time.

2.3. Experimental design, animals and management

Before the beginning of the trial animals were blocked according their age in order to guarantee that all rams were in postpubertal phase and had achieved semen patterns inherent to adult semen donors. Sixteen clinically healthy rams (*Ovis aries*) aging 12.0 ± 3.9 months at essay starting point were used in the study. The animals were split into two experimental groups according to their breed: Santa Inês group (SIN, n = 9; 51.0 ± 3.8 kg, black coat) and Morada Nova group (MON, n = 7; 40.6 ± 4.3 kg, red coat). Both genotypes have been described in Brazil and are hair sheep breeds. The Morada Nova and Santa Inês are indigenous breeds developed in Brazil. They are hair breeds with short and silky hair coat (Ribeiro and González-García, 2016). The Morada Nova is a medium frame pooled breed presenting coat color of various shades of red, and a white variety is also available. Average body height of the mature ewes is around 61 cm, and around 65 cm for the rams. In turn, Santa Ines colors range from red, black and white and can be spotted or solid. Animal are long-legged and are polled. Mature weights of Santa Inês ewes and rams are 40–50 kg, and 80 kg, respectively (ARCO, 2017).

Over one year, during the four climate seasons, sweating rate, physiological parameters, semen quality, and testicular parenchyma integrity were monitored. The data on sweating and physiological variables were obtained in monthly measurements taken in the morning and afternoon. Semen collections and sperm assessments were carried out monthly. The ultrasound analysis of the testes was also performed monthly, but was restricted to the months of summer and winter to favor the observation of possible contrasts. Later, the monthly data were grouped by climate season for the evaluation of the variables and comparison among seasons. The meteorological variables were continuously monitored during the experimental period.

All rams were semi-confined in a single lot within a 900 m^2 pasture with minimum natural shade. The diet consisted of roughage (*Cynodon nlemfuensis* grass and corn silage) and concentrate at 2% of the live weight (ground corn, soybean meal, calcitic lime, and mineralized salt). The animals were fed twice a day (9:00 a.m. and 4:00 p.m.) and had free access to the feeding trough and water *ad libitum* in an automated drinking trough.

2.4. Sweating rate and physiological variables

In order to assess thermolytic function, the animals were gently led to and restrained at a livestock crush immediately prior to the collections. The variables described below were measured in monthly campaigns over five consecutive days in the morning (8:00–9:00 a.m.) and afternoon (2:00–3:00–p.m.) (McManus et al., 2009). The sweating rate (SR, $g/m^2/h$) was measured in the scapular region after trichotomization according to Schleger and Turner (1965). Respiratory rate (RR, breaths/min) was obtained by counting the respiratory movements for one minute by an observer closely positioned in front of the animal. Rectal temperature (RT, °C) was determined using a clinical veterinary thermometer until the stabilization of the mercury column. Heart rate (HR, beat/min) was measured by counting the heart beats for one minute with a veterinary stethoscope (Correa et al., 2013). The same experienced veterinarian measured and registered SR, RR, RT and HR throughout the experimental period.

The body surface temperatures monitored were forehead temperature (FHT, °C), hair coat temperature (HCT, °C) and skin temperature (SKT, °C). Scrotal surface temperatures were also measured, divided into spermatic funicle temperature (SFT, °C), proximal pole testicular temperature (PPT, °C), distal pole testicular temperature (DPT, °C), and epididymal tail temperature (ETT, °C). Those temperatures were measured in real time by means of a digital infrared thermometer (Martello et al., 2010) with laser aim (ST-600, Incoterm, Porto Alegre, Brazil). The thermometer was positioned perpendicularly 20 cm from the focal point to be analyzed (distance:size rate = 12:1), in accordance with the recommendations of the manufacturer. HCT and SKT were obtained in the interscapular region after pulling the hair apart so that the skin temperature could be measured. The measurement of SFT, PPT, DPT, and ETT comprised the bilateral analysis of the contralateral structures and the result for each structure was presented as the means.

Later, four temperature gradients were calculated (°C), namely: GRAD1 = difference between rectal temperature and spermatic funicle temperature; GRAD2 = difference between rectal temperature and distal pole of testis temperature; GRAD3 = difference between rectal temperature and epididymal tail temperature; GRAD4 = difference between proximal and distal poles of testis temperatures.

2.5. Semen collection and assessment

Semen quality was monitored every other week after collection using an artificial vagina (Jiménez-Rabadán et al., 2016). Each ejaculate (n = 202) underwent immediate analysis according to standard methods (CBRA, 2013). The following parameters were evaluated: total