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Application of thermolysis capacity test for Santa Ines, Dorper and White Merino ewes

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Abstract: Currently some changes in the climates of different regions of the planet are observed and it is necessary a better knowledge of the species and breeds that have genetic potential with greater adaptability capacity, and are able to survive, produce and reproduce in a climate of harsh conditions, especially in environments tropical and intertropical. Thus, it becomes indispensable to know the adaptability of species and breeds explored in Brazil. The aim of this study was to evaluate the thermolysis capacity of Santa Ines, Dorper and White Merino sheep breed. Seventy five non-pregnant females (3 years old) were used in the study during summer. The test consists in evaluating the rectal temperature in three days of sun exposure after two hours under the shade (RT1) one hour under the sun (RT2) fifteen (RT3) and thirty (RT4) minutes after sun exposure, under the shade. The average RT1 were similar to the Santa Ines and Dorper sheep and superior to the White Merino sheep ($P<0.05$). To RT2, RT3 and RT4 the White Merino sheep had the highest values, followed by Santa Ines and the Dorper breed ($P<0.05$). These results reflected in individual thermolysis capacity index lower for Santa Ines ($P<0.05$). The results showed that even hair breed of tropical origin is affected by sun exposure. However, sheep are able to return to the initial physiological values quickly showing different degrees of resistance to thermal variation.

Keywords: adaptability, bioclimatology, heat stress, sheep, thermoregulation

Introduction

Livestock production in the tropics is mainly limited by high levels of solar radiation and temperatures that could adversely affect livestock production when compared to the animals in temperate zones (McManus et al, 2009).

Each specie has a comfort temperature called thermoneutral zone, defined as the temperature range in which the production is great and the energy expenditure for thermoregulation is low. Nevertheless, sheep may suffer in some situation as environmental temperatures may be above the comfort zone, which is between 20 and 30 °C (Baeta and Souza, 1997), with the higher critical temperature of 34°C, when heat stress is considered a factor of limiting production for sheep.

Adaptability of animals to hot environments can be found by physiological adaptability tests or heat tolerance and one of these is the heat tolerance index (Baccari Junior, 1990). The more tolerant to heat the more productivity can be the sheep in a tropical climate. Thus, it becomes indispensable to know the adaptability of the specie and breeds explored in a tropical climate. Therefore, the aim of this study was to apply a thermolysis capacity test for Santa Ines, Dorper and White Merino sheep.

Material and methods

The experiment was divided into 3 stages. The first stage was conducted in the Agrarian School of Beja (ESAB), in Beja city, Portugal, located at 38°00'43" North, 7°52'24" West and 244 meters above sea level. This step took place in July, the month of highest incidence of solar radiation (summer) in Portugal, and 25 Merino ewes was used in the thermolysis capacity test. The second stage was done with 25 Santa Ines ewes on Biometeorology and Ethology Laboratory of Faculty of Animal Science and Food Engineering of University of Sao Paulo in Pirassununga-SP, Brazil, at 21°57'04" South, 47°27'09 " West and 606.25 meters above sea level. This step was conducted from November to January, months of high incidence of solar radiation (black globe thermometer above 45 °C). The third stage of the experiment was to evaluate the thermolysis capacity of 25 Dorper breed ewes in February and March. This step was

carried out on the property Dorper Campo Verde, located in the city of Jarinu-SP, Brazil at 23°08'47" South, 46°48'20" West and 755 meters a.s.l.

All animals had similar body condition and coat color (Merino/white; Santa Ines/black; Doper/white with black head).

The thermolysis capacity test applied was adapted from the test proposed to sheep by Veríssimo (2008). The animals were brought in from pasture 11:00 am and remained two hours under the shade until 13:00, where rectal temperatures were measured (RT1) with clinical thermometers which were inserted into the animal's rectum remaining until the buzzer temperature stabilization. Soon after, the animals were released in a cemented yard without shade exposed to the sun for an hour, from 13:00 until 14:00, during the highest incidence of solar radiation time. Soon after, it was taken the second rectal temperature (RT2). After that, as the animals remained in the shade, every fifteen minutes two more rectal temperatures (RT3 and RT4) were taken. The thermolysis capacity index was calculated based by the formula, ICT = 10 - (RT4 - RT1), indicating the ability of the animal has to lose heat and restore normal body temperature after the end of exposure stressful solar radiation. The average of the 3 indexes of each animal was used to determine the individual thermolysis capacity index.

Black globe temperature, in the shade and in the sun, was recorded during the test; air temperature and relative humidity were measured with a thermohygrometer and air velocity with the anemometer. The test was performed on sunny days, no cloudiness and low airspeed.

For thermolysis capacity test was conducted an analysis of variance with fixed effects and sampling times (1, 2, 3 and 4), the date of test as a random effect and the animal as repeated measures and multiple comparison test means between the different times of samplings by the Tukey-Kramer test. The air temperature and black globe temperature were tested as a covariate, as though they did not have interference in the model they were excluded. The model is suitable for normal distribution.

For comparisons between the breeds an analysis of variance was done for measures of thermolysis capacity test and multiple comparison test of means between the different times of sampling by the Tukey-Kramer test.

The significance level used in the experiment was 5% and all experimental results were presented as mean and standard error. Statistical analyzes of the results were performed using the PROC GLM Procedure (SAS, 2000).

Results and Discussion

The mean of the climatic variables: air temperature, black globe temperature in the sun, black globe temperature in the shade, relative humidity and wind speed were registered in the same time of thermolysis capacity test and they are presented in Table 1.

Table 1. Means values climate variables during the days of thermolysis capacity test for the studied breeds.

Breed	**Santa Inês**				**Merino Branco**				**Dorper**			
Horário	**11h00**	**13h00**	**14h00**	**15h00**	**11h00**	**13h00**	**14h00**	**15h00**	**11h00**	**13h00**	**14h00**	**15h00**
BGTsb	31.00	32.50	31.83	32.00	32.50	35.67	36.67	43.33	26.30	29.70	29.80	29.00
BGTs	40.00	43.67	45.67	42.60	41.67	46.33	46.00	46.00	38.30	44.30	43.30	45.00
RH	47.33	41.33	34.33	37.00	38.15	34.40	30.55	31.20	54.30	47.00	46.70	52.00
Tar	28.63	30.17	32.13	31.43	-	-	-	-	26.00	29.00	29.00	26.90
Wind	0.13	0.13	0.33	0.50	-	-	-	-	-	-	-	-
BGTUsb	79.17	80.01	78.00	78.65	79.44	82.42	82.72	90.32	74.00	77.40	77.60	77.30
BGTUs	90.68	93.63	93.90	91.12	90.33	94.69	93.10	93.31	90.20	96.10	94.70	82.80

BGTsb: black globe temperature in the shade; BGTs black globe temperature in the sun; RH: relative humidity; Tar: air temperature; BGTsb: black globe temperature and humidity index in the shade; BGTUs: black globe temperature and humidity index in the sun.

It was observed that there were favorable weather conditions for a thermolysis capacity test, with high temperatures, low humidity, low wind speeds and no cloud cover, to carry out all stages of the experiment. The days were considered equal for the climate variables in the harvesting zones ($P>0.05$).

The largest black globe temperature records in the sun (BGTs) occurred during the hours between 13:00 and 15:00, also coinciding with the higher temperature of the black globe in the shade (BGTsb). In contrast, in those times the relative humidity values (RH) were the lowest.

For the globe index and humidity values in the sun (BGTUs) the greatest records were found at the same times of the greatest BGTs values, reaching values above 93 on the exposure time to the sun (13h00 to 14h00) for every day of harvest .

In the globe and humidity index in the shade (BGTUsb) the values found were high since the start of data collection at 11.00, reaching maximum values between 77.6 and 94.7.

Baêta and Souza (1997) published several critical values for BGTU based on studies with cattle, where values between 74-78 is a range require care for the animals, 79-84 is considered dangerous to the physiology of the animal and rates above 85 are the range considered emergency heat stress when steps should be taken to prevent harm to the animals.

César et al. (2004), in semi-arid conditions, with BGTU ranging from 75.5 and 82.4, defined alert conditions and thermal danger to sheep of the Dorper and Santa Ines crossbred, adopting the American classification of thermal comfort index.

On Table 2 it was found that there was difference in rectal temperatures of all three breeds studied. For the first rectal temperature, with two hours of rest in the shade (RT1), White Merino breed had higher RT ($P<0.05$), followed by Dorper and Santa Ines, with no differences between this two breeds ($P>0.05$). With an hour under the sun (RT2) the White Merino breed continued with the highest RT, but at this time there was difference between the Santa Ines and Dorper ($P>0.05$). The temperature reduced after fifteen (RT3) minutes of rest in the shade for Santa Ines and Dorper ewes ($P<0.05$), and for White Merino only after thirty minutes (RT4; $P<0.05$).

Table 2 - Mean values standard and error of rectal temperature (RT °C) during the of thermolysis capacity test for the studied breeds.

	Santa Ines		White Merino		Dorper	
Group	**Means**	**error**	**Means**	**error**	**Means**	**error**
RT 1	38.63 cB	0.018	39.08 cA	0.043	38.53 dB	0.046
RT 2	39.19 aB	0.019	39.38 aA	0.035	39.03 aC	0.047
RT 3	39.03 bB	0.026	39.29 abA	0.044	38.83 bC	0.042
RT 4	38.96 bB	0.028	39.19 bcA	0.041	38.68 cC	0.040

Means followed by different lower-case letter in column, differ by Tukey-Kramer Test ($P< 0.05$).
Means followed by different uppercase letter in line, differ by Tukey-Kramer Test ($P< 0.05$).

The mean rectal temperatures found for the Santa Ines two hours under the shade (RT1) was similar to the temperature found by Veríssimo (2008) of 38.64 °C. However, soon after sun exposure for one hour (RT2), the average was 0.46 higher than the value found by Veríssimo (2008). As Santa Ines used in this experiment were all dark hair coat color, this characteristic may have contributed to greater acquisition of heat in the sun. A dark pigmentation has a higher absorption of solar radiation shortwave and therefore holds larger amount of thermal energy than a lighter-colored cover, which has a higher reflection (McManus et al., 2009)

On the other hand, the rectal temperature of the Santa Ines and Dorper after fifteen and thirty minutes of rest in the shade were still higher than the first temperature in the shade ($P<0.05$), indicating that thirty minutes is not enough for the animals to return the temperature values collected before exposure to heat stress. As for the White Merino breed, thirty minutes were enough for the reduction of RT ($P>0.05$). In a similar study, it took forty five minutes for the sheep to reduce the rectal temperature values to equal values before the test for hair breeds, and for wool breeds sheared and unsheared (Veríssimo, 2008).

The elevated rectal temperature reflects heat accumulation in the animal organism, which results from the excess heat received from the environment, plus the internal heat during the day, and the inability of thermoregulatory mechanisms to dissipate any excess heat received (Baêta & Souza, 1997).

Thus, the increase in temperature during the day has an effect on rectal temperature of Santa Ines ewe, with higher values in the afternoon (Cezar et al., 2004). Although the initial rectal temperature was different for the three breeds, they range between 38.5°C and 39.9°C, a normal value for sheep.

To calculate the TCI it was used the initial rectal temperature values, with two hours of rest in the shade (RT1) and rectal temperature thirty minutes of rest in the shade (RT4) (Table 3).

Table 3 - Thermolysis capacity index ad rectal temperature in the breeds Santa Ines, White Merino and Dorper.

	Santa Ines	**White Merino**	**Dorper**
Rectal temperature (RT1, °C)	38.63	39.08	38.53
Rectal temperature (RT4, °C)	38.96	39.19	38.68
Thermolysis capacity index	**9.67 b**	**9,89 a**	**9.88 a**
EPM	0.035	0.031	0.028

Means followed by different lowercase differ by Tukey- Kramer Test (P< 0.05).

The TCI data showed that all three breeds of sheep studied have a high degree of thermolysis capacity, with maximum 9.89 and minimum 9.67(P< 0.05), as the maximum index value is 10.

The thermolysis capacity value found for Santa Ines breed is consistent with those found by Verissimo (2008) of 9.66. Verissimo (2008) also found high values for TCI in wool breeds such as Ile de France, Suffolk and Texel. Sheep with wool, when there is no shade available, had more protection from the effects of solar radiation than hair breeds, as the wool acts as an efficient thermal insulator.

Conclusions

Under the climatic conditions of the experiment, Dorper and White Merino breed showed higher thermolysis capacity than Santa Ines, and coat color is a factor that can influence the individual heat tolerance.

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