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Research Article

Physiological Parameters in Different Breeds of Rams as a Measure of Adaptation to Environmental Conditions in the Federal District-Brazil

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Abstract: This study aims to assess relationships between some aspects of physiology and haematology of rams from different breeds, as well as the possible influences of environmental and climatic conditions (dry or wet seasons) on animal physiology. Eighteen purebred rams from six different breeds (Santa Inês, Bergamasca, Hampshire Down, Texel, Ilê de France and Dorper) and origins were used in two seasons in Central Brazil. Body Weight (BW), Rectal Temperature (RT) and blood parameters were measured and compared their selves between dry and wet seasons and between breeds. BW, RT, RBC (red blood cells), MCV (mean corpuscular volume), MCHC (mean corpuscular haemoglobin concentration) and TPP (total plasma protein) were highly significant ($p<0.001$) between different breeds. Season did not significantly ($p>0.001$) affect BW, RT, PCV (packed cell volume), RBC, Hb (haemoglobin) and PPT. The effect of season on breed was significant ($p<0.01$) for BW, PCV, RBC and Hb. Hair breeds such as Santa Inês (SI) had greater adaptability to climatic conditions in the region in comparison with other breeds and this reinforces the importance of breeding programs taken in account the characteristics expressed in the place where animal will live.

Keywords: Adaptation, breeds, physiological parameters, rams

INTRODUCTION

Sheep production in the center west region of Brazil is increasing (FNP Institute, 2010). However, any animal production in this region should take in account harsh climatic conditions (McManus *et al*., 2011a, b) such as high solar radiation and daily temperatures (including high daily amplitude-Paim *et al*., 2013), poor quality forage (Menezes *et al*., 2013), as well as long dry periods, which may affect production levels.

Animals which show adequate adaptation to adverse climatic conditions should have a production advantage over non-adapted animals (Correa *et al*., 2012; McManus *et al*., 2009; Paiva *et al*., 2005), especially with the present scenario of climatic changes and global warming (Scholtz *et al*., 2011). While sheep farming in the center west was originally based on hair breeds, especially Santa Inês, the need for improve carcass quality and higher growth rates has led to the use of animals from other breeds (McManus *et al*., 2010), including wool breeds. However, information on these animals in the adverse climatic conditions of center west region is still scarce.

According to Marai *et al*. (2007), thermal tolerance, longevity and adaptation have direct relationship with physiological responses of the animals to their environment such as temperature, humidity and solar radiation. In addition, it is known that animals respond differently when they are frequently exposed to environmental factors that can affect physiological traits, behavior and productivity. Animals reared under different climatic conditions can present clear variations in some physiological measures, mainly in blood

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constituints. Due these variations, the study of physiological characteristics and haematological values of native and exotic breeds, in center west of Brazil, have fundamental importance for the determination of genotypes adapted to these conditions or even to mitigate the discomfort and thermal stress, improving the well-being. This study was conducted to examine relationships between some aspects of physiology and haematology of different sheep breeds as well as the possible influences of environmental and climatic conditions (dry or wet seasons) on animal physiology.

MATERIALS AND METHODS

This study was carried out during three consecutive days in May (period I-end of wet season) and August (period II-end of dry season) on the Sucupira experimental farm (EMBRAPA/CENARGEN) and the Veterinary Hospital of the University of Brasilia (FAV-UnB), in the Federal District, Brazil. The climate of the region is Köppen Aw (tropical rainy), with dry winters and rainy summers, average altitude of 1,100 m and average annual rainfall approximately 1,493 mm.

The records of air temperature (T_{air}-°C) and relative humidity (RH-%) were performed every 30 min using a digital thermal hygrometer and the Temperature

Humidity Index (THI) was calculated according Kelly and Bond (1971).

Eighteen adult rams (approximately 3 years of age) were used in groups of three rams from each of six different breeds of sheep: Santa Inês (SI), Bergamasca (BER), Ilê de France (IF), Texel (TX), Dorper (DR) and Hampshire Down (HD). These rams were bought from different sources in Brazil and had no parentage for at least three generations. All animals were kept under semi-extensive systems. All measurements (body weight-BW-and rectal temperature-RT), blood sampling and climatic parameters started at 6 am and ending up at 10 am.

Blood samples were obtained by jugular puncture using vaccum tubes containing EDTA (vacuntainer®) and aliquots were separated for smear preparation and blood count. Red Blood Cells (RBC), Leukocytes (LEU), Haemoglobin (Hb), Mean Corpuscular Volume (MCV) and mean corpuscular haemoglobin concentration (MCHC) were determined using an automated cell counter (ABCVeet-ABX®). Packed Cell Volume (PCV) was measured based on the technique described by Wintrobe (Birgel, 1982). Smears for differential leukocyte counts (monocytes-MON, lymphocytes-LYM, eosinophils-EOS and neutrophils-NEU) were stained with rapid panotype and Total Plasma Protein (TPP) was determined using a refractometer.

Table 1: Means and Standard Deviations (SD) of climate measures during the trial

	Period	Mean*	SD	Minimum	Maximum	p-value
T_{air} (ºC)	I	21.56a	0.53	20.9	22.2	<0.0001
	II	8.96b	2.17	6.8	11.9	
RH (%)	I	59.33a	6.29	51	66	<0.0001
	II	71.66b	3.89	68	77	
THI	I	20.65a	0.33	20.21	21.02	<0.0001
	II	9.44b	1.97	7.55	12.13	

* Different letters (a,b) in the same column and parameter, differs significantly. T_{air} = air temperature; RH = Relative Humidity; THI = Temperature Humidity Index

Table 2: Comparisons between body weight and rectal temperature in different breeds of sheep in the Federal District (Brazil) at the end of the wet and dry seasons (periods I and II)

	BW			RT		
Period	**			**		
Breed	***			***		
Period x Breed	**			ns		
CV	12.98			1.24		
Period						
I	76.7a			38.53a		
II	81.9b			38.18b		
		Period			Period	
Breed	Mean	I	II	Mean	I	II
BER	65.0a	58.2a, A	71.8a, B	38.5a, c	38.5a, b, A	38.3a, A
DR	76.9b	71.8b, A	82.0b, B	38.2a	38.2b, A	38.0a, A
HD	90.5c	87.3c, d, A	93.8c, B	38.7b, c	38.8a, A	38.6a, A
IF	89.4c	95.8d, A	83.0d, A	38.5a, c	38.9a, A	38.0a, B
SI	75.8b	72.1b, A	79.5e, B	37.4d	37.4c, A	37.2b, A
TX	77.5b	75.1b, c, A	80.0f, A	39.0b	39.3d, A	38.6a, A
Reference values	-			38.3-39.9†		

BW = Body Weight (kg); RT = Rectal Temperature (oC); ns = not significant; * p<0.05; ** p<0.01; *** p<0.001; CV = Coefficient of Variation; BER = Bergamasca; DR = Dorper; HD = Hampshire Down; IF = Ile de France; SI = Santa Ines; TX = Texel; Means in the same column followed by different lower case letters (a, b, c, d) represent significant differences (p<0.05) by Duncan test; Means in the same line to the same parameter followed by different upper case letters (A,B), represent significant differences (p<0.05) by Duncan test. †According to Marai *et al*. (2007)

Statistical analyses were conducted using SAS® (Statistical Analysis Institute, Cary, North Carolina). PROC MIXED with 0.05 significance level was used for the analysis of variance. Means were compared using Duncan test. Principal components (PRINCOMP) were calculated. Canonical and discriminant analyses were also performed to evaluate the characteristics that affect the differences between breeds.

RESULTS

There was a considerable decrease in the mean of T_{air} and an increase in RH from period I to period II. Temperature reduction was accompanied by a decrease in mean of THI from period I to period II (Table 1).

Body Weight (BW) and Rectal Temperature (RT) were different between periods and breeds (Table 2). BW mean was 5.2 kg lower on period I, while mean difference in RT between periods I and II were very small: only 0.35°C. RT were lower (thereabout 1°C) in SI when compared with other breeds in both, period I and II. In the other hand, for the hottest period (period I), TX showed the highest RT. There was as interaction between period and breed influencing BW. Period influenced PCV, RBC, Hb, MCHC and TPP while breed was important to RBC, MCV, MCHC and TPP (Table 3).

In general, blood parameters measured were within the reference values described by Jain (1993) and were lower in period I. The means of PCV did not show significant difference between breeds but, unlike the period II, period I presented some difference between breeds. Similar results (difference between breeds only on period I) were seen for TPP. For RBC, although SI showed the highest values, it was not enough to be different from BER and DR. DR presented the lowest values of MCV in period I and II. In relation to MCHC, they showed higher values in both (period I and II). Significant differences between breeds for LEU, LYM and NEU were seen (Table 4). Betwee periods, significant differences were found for LYM, NEU and for EOS.

Principal component analysis presented an association between high LEU, NEU, TPP and LYM and low MCV with animals with higher RT (the

Table 3: Comparisons between blood parameters in different breeds of sheep in the Federal District (Brazil) at the end of the wet and dry seasons (periods I and II)

	PCV			RBC			Hb		
Period	***			***			***		
Breed	ns			*			ns		
P x B	*			*			*		
CV	14.01			13.82			24.07		
Period									
I	26.88^{a}			8.26^{a}			8.86^{a}		
II	34.37^{b}			9.47^{b}			10.66^{b}		
		Period			Period			Period	
Breed	M	I	II	M	I	II	M	I	II
BER	31.6^{a}	26.2^{a,b,A}	36.3^{a,B}	9.1^{a,b}	8.0^{a,b,A}	10.1^{a,b,B}	9.9^{a}	8.6^{a,A}	11.1^{a,B}
DR	29.7^{a}	24.3^{b,A}	35.1^{a,B}	8.5^{b}	8.1^{a,b,c,A}	9.0^{a,b,c,A}	9.7^{a}	8.5^{a,A}	11.0^{a,B}
HD	31.9^{a}	29.4^{c,A}	34.4^{a,B}	8.9^{a,b}	8.8^{c,A}	9.0^{a,b,c,A}	9.8^{a}	9.6^{b,A}	10.1^{a,A}
IF	29.6^{a}	25.5^{a,b,A}	33.6^{a,B}	8.5^{b}	7.5^{a,A}	9.4^{a,b,c,B}	9.3^{a}	8.3^{a,A}	10.4^{a,B}
SI	31.1^{a}	27.7^{b,A}	31.7^{a,A}	9.6^{a}	9.7^{b,c,A}	10.7^{a,B}	10.1^{a}	9.0^{a,b,A}	13.6^{a,A}
TX	30.2^{a}	28.0^{b,c,A}	32.4^{a,A}	8.3^{b}	8.2^{a,b,c,A}	8.5^{c,A}	9.5^{a}	9.0^{a,b,A}	9.9^{a,A}
REF	24-50†			8-16†			8-16†		

	MCV			MCHC			TPP		
Period	ns			**			*		
Breed	***			***			**		
P x B	ns			ns			ns		
CV	4.37			13.02			9.1		
Period									
I	32.45^{a}			33.17^{a}			7.70^{a}		
II	32.05^{a}			35.55^{b}			7.33^{b}		
		Period			Period			Period	
Breed	M	I	II	M	I	II	M	I	II
BER	32.5^{a,b}	32.6^{a,b,A}	32.5^{a,A}	33.2^{a}	32.8^{a,A}	33.7^{a,A}	7.3^{a,b}	7.5^{a,b,A}	7.1^{a,A}
DR	30.1^{c}	29.8^{c,A}	30.4^{b,A}	38.0^{b}	35.4^{b,A}	42.3^{b,A}	7.0^{b}	7.0^{b,A}	7.0^{a,A}
HD	32.8^{a,b}	33.0^{a,b,A}	32.6^{a,A}	33.3^{a}	32.7^{a,A}	33.8^{a,A}	7.4^{a,b}	7.6^{a,b,A}	7.1^{a,A}
IF	32.8^{a,b}	33.6^{a,A}	32.0^{a,B}	33.7^{a}	33.0^{a,A}	34.5^{a,A}	7.5^{a,b,c}	7.6^{a,A}	7.5^{a,A}
SI	31.8^{b}	31.7^{b,A}	31.9^{a,A}	32.7^{a}	32.4^{a,A}	30.2^{a,A}	8.0^{c}	8.3^{a,A}	8.1^{a,A}
TX	33.3^{a}	33.9^{a,A}	32.7^{a,A}	34.1^{a}	32.5^{a,A}	35.8^{a,B}	7.8^{b,c}	7.9^{a,A}	7.6^{a,A}
REF	23-48†			31-38†			6-7.5†		

PCV= Packed Cell Volume (%); RBC = Red Blood Cells (unitsx106/μL); Hb = haemoglobin concentration (g/100 mL); MCV = Mean Corpuscular Volume (fL); MCHC = Mean Corpuscular Haemoglobin Concentration (%); TPP = Total plasma protein concentration (g/100 mL); BW = Body Weight (kg); PxB = period x breed effect; ns = not significant; * $p<0.05$; ** $p<0.01$; *** $p<0.001$; CV = Coefficient of Variation; M = means; BER = Bergamasca; DR = Dorper; HD = Hampshire Down; IF = Ile de France; SI = Santa Ines; TX = Texel; REF = reference values; Means in the same column followed by different lower case letters (a, b, c, d, e, f) represent significant differences ($p<0.05$) by Duncan test; Means in the same line to the same parameter followed by different upper case letters (A, B), represent significant differences ($p<0.05$) by Duncan test. †According to Jain (1993)

Table 4: Comparisons between leukocyte parameters in different breeds of sheep in the Federal District (Brazil) at the end of the wet and dry seasons (periods I and II)

	LEU			MON			LYM		
Period	ns			ns			***		
Breed	***			ns			***		
P x B	**			ns			Ns		
CV	32.11			72.24			36.62		
Period									
I	9.36^{a}			240.3^{a}			2872.1^{a}		
II	8.56^{a}			242.3^{a}			3691.1^{b}		
		Period			Period			Period	
Breed	Mean	I	II	Mean	I	II	Mean	I	II
BER	9.07^{a}	8.3^{a,A}	9.8^{a,A}	230.6^{a}	137.1^{a,A}	312.3^{a,A}	3382.9^{a,b}	2602.4^{a,b,A}	4163.1^{a,b,B}
DR	8.49^{a}	8.5^{a,A}	8.4^{a,b,A}	244.4^{a}	210.1^{a,A}	267.2^{a,A}	2411.6^{d}	1774.0^{b,A}	3049.1^{b,B}
HD	8.52^{a}	8.5^{a,A}	8.4^{a,b,A}	168.3^{a}	200.8^{a,A}	144.0^{a,A}	4265.0^{c}	3778.6^{a,A}	4751.3^{a,A}
IF	7.27^{a}	7.41^{a,A}	7.14^{b,A}	210.5^{a}	188.7^{a,A}	232.4^{a,A}	2979.4^{a,d}	2708.4^{a,b,A}	3250.4^{b,A}
SI	7.98^{a}	8.0^{a,A}	7.9^{a,b,A}	224.7^{a}	225.3^{a,A}	224.3^{a,A}	2781.2^{a,d}	2584.7^{a,b,A}	2977.5^{b,A}
TX	12.37^{b}	15.2^{b,A}	9.5^{a,B}	371.7^{a}	439.5^{b,A}	281.3^{a,A}	3869.6^{b,c}	3784.1^{a,A}	3955.0^{a,b,A}
REF	4000-12000†			0-750†			2000-9000†		
	EOS			NEU					
Period	*			***					
Breed	ns			***					
P x B	ns			*					
CV	73.76			51.56					
Period									
I	663.5^{a}			5835.5^{a}					
II	453.5^{b}			4082.6^{b}					
		Period			Period				
Breed	Mean	I	II	Mean	I	II			
BER	702.8^{a}	821.3^{a,A}	584.2^{a,b,A}	4791.7^{a}	4763.2^{a,A}	4820.1^{a,A}			
DR	621.3^{a}	789.8^{a,A}	452.7^{a,b,A}	4980.1^{a}	5862.6^{a,A}	4097.5^{a,A}			
HD	549.5^{a}	718.5^{a,A}	359.3^{a,b,B}	3925.5^{a}	4589.0^{a,A}	3262.0^{a,A}			
IF	404.8^{a}	382.5^{a,A}	422.0^{a,b,A}	3746.1^{a}	4217.2^{a,A}	3274.8^{a,A}			
SI	368.1^{a}	469.2^{a,A}	266.8^{b,A}	4615.2^{a}	4715.7^{a,A}	4514.5^{a,A}			
TX	720.6^{a}	774.3^{a,A}	674.5^{a,A}	7696.1^{b}	10865.3^{b,A}	4526.7^{a,B}			
REF	0 - 1000†			700 - 6000†					

LEU= leukocytes (units x 103/μL); MON = monocytes (unitsx103/μL); LYM = lymphocytes (units x 103/μL); EOS = eosinophils (unitsx103/μL); NEU = neutrophils (units x 103/μL); PxB = Period x Breed effect; ns = not significant; *p<0.05; **p<0.01; ***p<0.001; CV = Coefficient of Variation; BER = Bergamasca; DR = Dorper; HD = Hampshire Down; IF = Ile de France; SI = Santa Ines; TX = Texel; REF = reference values; Means in the same column followed by different lower case letters (a, b, c, d) represent significant differences (p<0.05) by Duncan test; Means in the same line to the same parameter followed by different upper case letters (A,B), represent significant differences (p<0.05) by Duncan test. †According to Jain (1993)

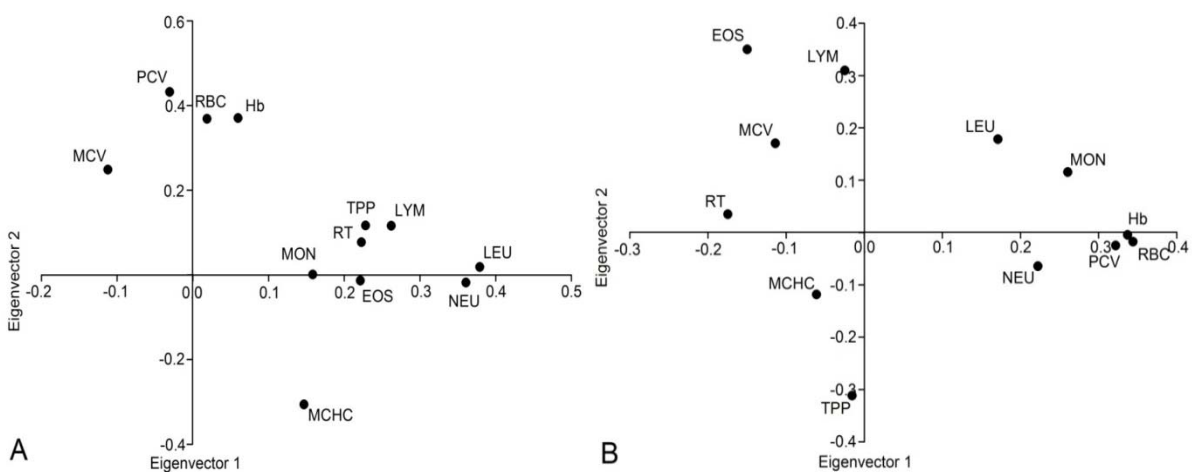

Fig. 1: Eigenvectors for period I (A) and II (B) in six breeds of sheep for Rectal Temperature (RT) and hematological parameters. PCV = Packed Cell Volume; Hb = haemoglobin; RBC = Red Blood Cells; MCV = Mean Corpuscular Volume; MCHC = Mean Corpuscular Haemoglobin Concentration; LEU = Leukocytes; MON = Monocytes; LYM = lymphocytes; EOS = eosinhophils; NEU = neutrophils; TPP = Total Plasma Proteins

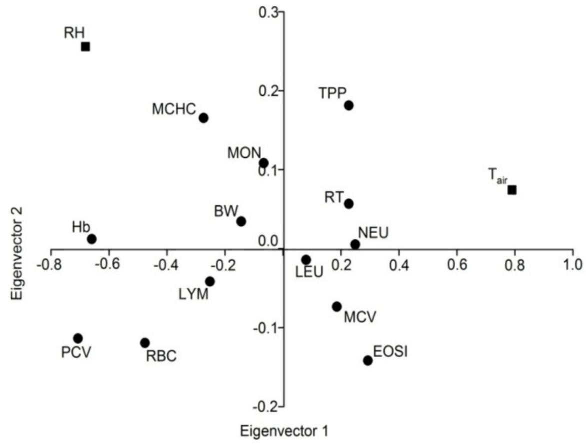

Fig. 2: Discriminant analysis of blood and climatic parameters in both seasons. PCV = Packed Cell Volume; Hb = haemoglobin; RBC = Red Blood Cells; MCV = Mean Corpuscular Volume; MCHC = Mean Corpuscular Haemoglobin Concentration; LEU = leukocytes; MON = monocytes; LYM = lymphocytes; EOS = eosinhophils; NEU = neutrophils; TPP = Total Plasma Proteins; RH = Relative Humidity; BW = Body Weight; RT = Rectal Temperature; T_{air} = Air Temperature

Table 5: Percentage of animals classified in each breed during period I

Period I						
Breed	BE	DR	HD	IF	SI	TX
Breed	BE	DR	HD	IF	SI	TX
BE	88.89	0.00	0.00	0.00	0.00	11.11
DR	22.22	77.78	0.00	0.00	0.00	0.00
HD	0.00	0.00	77.78	11.11	0.00	11.11
IF	0.00	0.00	22.22	66.67	0.00	11.11
SI	0.00	0.00	0.00	0.00	100.00	0.00
TX	11.11	0.00	0.00	11.11	0.00	77.78

Table 6: Percentage of animals classified in each breed during period II

Period II						
Breed	BE	DR	HD	IF	SI	TX
BE	100.00	0.00	0.00	0.00	0.00	0.00
DR	25.00	75.00	0.00	0.00	0.00	0.00
HD	0.00	0.00	100.00	0.00	0.00	0.00
IF	0.00	0.00	16.67	83.33	0.00	0.00
SI	0.00	0.00	0.00	0.00	100.00	0.00
TX	0.00	0.00	0.00	0.00	0.00	100.00

first eigenvector-Fig. 1a). High PCV, RBC and Hb were associated with low MCHC (second eigenvector-Fig. 1a and first eigenvector-Fig. 1b). For period II (Fig. 1b), red blood parameters (RBC, Hb and PCV) were allocate far away from RT (First eigenvector) while high EOS and LYM had low TPP (second eigenvector).

Red blood cells-associated parameters (e.g., Hb, PCV, RBC) showed some discriminatory capacity (Fig. 2). On the other hand, leukocyte count and its suubgroups showed low discriminatory capacity.

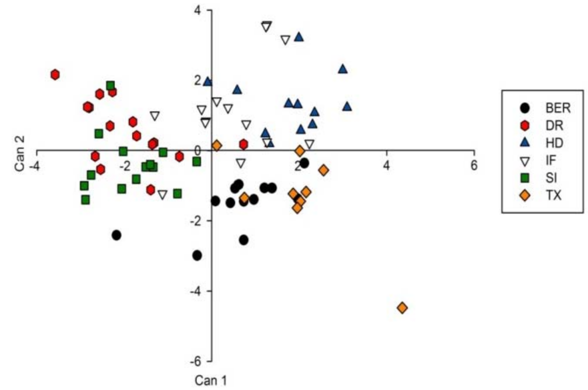

Fig. 3: Discriminant analysis by breed using all measure traits. BER = Bergamasca; DR = Dorper; HD = Hampshire Down; IF = Ilê de France; SI = Santa Inês; TX = Texel

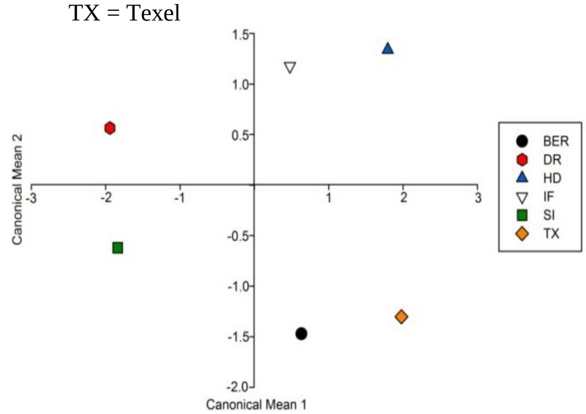

Fig. 4: Mean discriminant analysis by breed. BER = Bergamasca; DR = Dorper; HD = Hampshire Down; IF = Ilê de France; SI = Santa Inês; TX = Texel

In general, more than 75% of the animals studied were correctly classified in their breeds (Table 5 and 6) in both periods of study with exception of IF on period I (66.6%). SI was not wrong classified in any period. Figure 3 and 4 shows the discriminant analysis using all measured traits and by breed, respectively.

DISCUSSION

The ability to adapt in adverse conditions is an important characteristic in all livestock production systems, in particular when the landscape presents high climatic variations: animals well adapted have better production results when challenged compared with non-adapted animals. Although animals in this experiment were not under heat stress during the data collection-according to Marai *et al*. (2007), THI values below 22.2 indicate absence of heat stress-the great variation in climatic parameters between periods (12.6°C mean Tair difference and 11.21 in THI mean difference) ensures that animals used here were under climatic challenge and thus, breed differences could be evaluated.

For example, the climatic changes between period I and period II associated with a probably low ability of adaptation to high temperatures during the day-data from INMET (Instituto Nacional de Metereologia) (2013) indicate that temperature in Federal District during the day reached the maximum 27.7°C on period I-can explain the body weight loss registered in IF: high T_{air} causes an increase on heat load with a reduction in the thermal gradient between body core and environment, resulting in reduced ability for sensitive heat loss. In this case, the immediate response of animals is the decrease of food intake in attempt to bring metabolic heat production in line with the capacity for heat dissipation (NRC (National Research Council), 1981). The result of this could be seen on the subsequent period in the form of decreased body mass. Breeds such as SI, DR and BER have reared in stressful environments for many generations which may explain why these breeds did not lose weight.

RT of all breeds was within the expected range for sheep (34.8-39.9°C, according to Cunninghan (2004)). TX and SI breeds showed respectively the highest and the lowest RT means (39.0 and 37.4°C) corroborating with McManus *et al*. (2009) that observed more resistance of the hair breeds to high ambient temperatures compared to wool breeds. Higher values of RT in wool breeds may indicate a difficulty in adapting to the climatic conditions of the Federal District. This difference may be due the insulation provided by the wool, making difficult for wool breeds to sweat. However, although during the data collect T_{air} was lower, apparently, all animals presented an efficient thermoregulation mechanism by respiratory evaporation as sweating by skin is not efficient in wool breeds (Silva, 2000) and RT did not reach levels considered harmful-above 42°C (Thwaites, 1985).

Lower adaptation to heat stress in IF-which was also demonstrated by Neves *et al*. (2009) -could be involved with the RT difference between period I and II in this breed. While in all other breeds no significant difference in RT from one period to other was seen, for IF the decrease in this parameter was significant, showing that in the hottest period, RT was too high for animal to maintain regulate its temperature effectively. This could represent a manifestation of ability of this breed in conserving the body water (well adapted animals reduce their water loss by evaporation in order to chill the body when the temperature increases), but only if they were deproved water (Andersson and Jónasson, 1996) which is not the case with animals in this experiment. In this case, probably, heat load may increase the activity of the thyroid gland, resulting in a high metabolic rate which justifies the increase in RT (Ross *et al*., 1985) as well as BW loss.

It seems that almost all blood red series is influenced by the period with higher values in the colder season (Table 3). The changes in PCV, RBC and Hb values from period I and II were accompanied by changes in MCV and MCHC, since these are calculated using that values. Breed differences could be seen inside periods, especially in period I: as an example, PCV and TPP in period I suggest that the HD and TX were more dehydrated when compared with other breeds, perhaps due to evaporation losses. On the other hand, from one period to another, the increase in RBC, Hb and PCV can be explained by the probable reduction of water intake in the colder weather (period II). Data from period I corroborate this and suggest that animals were actually more hydrated due to the higher temperature in this period. Higher temperature triggers the adjustment of water balance through of cerebral thermal sensors. These sensors regulate thirst and vasopressin release that are interrelated in the hypothalamus (Baker, 1982). This depression in the PCV values was in agreement with results obtained by El-Nouty *et al*. (1990), who reported the same decline for cattle subjected to heat stress as a result of an adaptive mechanism to provide water needed for evaporative cooling process.

The TX was the only breed to present average levels of LEU and NEU above the reference values for the species and according to Jain (1993), leukocytosis usually occurs in stressed animals mediated by release of epinephrine and glucocorticoids, but this endogenous release of glucocorticoids that typically causes leukocytosis is accompanied by neutrophilia and lymphopenia. The latter was not detected. Moreover, catecholamines cause contraction of the spleen with release of erythrocytes in the peripheral circulation (Cross *et al*., 1988) which also was not observed in TX, but this can be an additional explanation for the high levels of PCV and Hb showed by HD during the period I (Table 3).

The evaluation of the WBC in the two periods (Table 4) indicates a physiological leukocyte response of all breeds, since the neutrophil/lymphocyte ratio (NEU:LYM) in ruminants is about 0.5 (Jones and Allison, 2007) and BER, for example, showed a ratio equal to 1.4. According to Batista *et al*. (2009), the relationship NEU: LYM can increase up to three times followed by a drastic reduction in the number of eosinophils indicating a concurrent infection. Here, this hypothesis was discarded because with exception to HD, no reduction in the number of eosinophils was seen and no animal showed signs of disease. However, according to Peinado *et al*. (1999), some studies on animals from the Order Artiodactyla show no clear trend for numbers of the two most abundant types of leukocytes and possibly the total leukocyte count and the ratio between the cell types can be influenced by exposure to diseases, management or even by breed factors.

The principal component analysis (Fig. 1) shows two different situations where white blood cells have a marked importance in distinguishing one from the other. In the first, the hottest period, NEU and LYM are relatively close each other showing a low ratio NEU:LYM while during the period II, these two parameters are very different from each other.

LEU did not show any discriminatory capacity (Fig. 2), perhaps due to the fact that, with exception of TX, all breeds were within the reference values. On the other hand, the red blood parameters (RBC, PCV, Hb and MCHC) showed good discriminatory capacity. This corroborates with results from blood traits where difference between breeds are well observed, especially in period I. This difference between breeds maybe related to the ability to adaptation to heat, as these parameters are modified by spleen contraction during exercise or exposure to heat. This is in agreement to Castanheira *et al*. (2010) who state that an increase in Hb is a result of physiological adaptation.

The discriminant canonical analysis (Fig. 3) shows closer distances between DR and SI, BER and TX and between HD and IF. In addition, little variation for the traits evaluated are seen when breeds are taken together two by two (Fig. 4). For these traits, to be hair or wool breed can explain why SI are closer to DR than the BER as SI is a breed originated from crosses between Bergamasca with Morada Nova and Criollo sheep (Morais, 2001; Paiva *et al*., 2005). In the same way, although the multivariate analysis did not commit any mistake between BER and SI classification and have more than 75% of the animals studied correctly classified in their breeds independently of the period (Table 5 and 6), the wool breeds showed some confounding.

Other studies comparing heat tolerance (Castanheira *et al*., 2010; Ravagnolo and Misztal, 2002) observed that genetic variation for heat tolerance was an important trait to sustain animal production, especially in tropical landscapes. The results reinforces this thesis as less adapted animals (wool breeds) seem to present greater energetic cost to sustain their temperature. This could be the reason that sometimes people use stereotypes and conclude that one specifically breed is unproductive. For the most, this result from animal breeding programs that imported exotic breeds, considered to be more productive, based on their performances in the environments of origin. The greater adaptability of the SI and lower adaptability of the TX corroborate these observations.

CONCLUSION

The use of some physiological characteristics and haematological parameters are valid tools when it comes to assessing the health of animals and comparing the adaptability to different environments. These results suggest a greater adaptability of SI breed to climatic conditions of the Federal District.

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REFERENCES

Andersson, B.E. and H. Jónasson, 1996. Regulação da temperatura e fisiologia ambiental. In: SWENSON, M.J. (Eds.), Dukes-fisiologia dos animais domésticos. 11th Edn., Rio de Janeiro, Guanabara Koogan, pp: 805-813.

Baker, M.A., 1982. Brain cooling in endotherms in heat and exercise. Annu. Rev. Physiol., 44: 85-96.

Batista, M.C.S., R.S. Castro, E.W. Rego, F.A.A. Carvalho, S.M.M.S. Silva, C.C.D. Carvalho and F. Riet-Correa, 2009. CBC, proteinograma, ionograma strengths and biochemical and enzymatic sheep acomentidos by conidiobolomicose in the northeast of Brazil. Msh. Vet. Bras., 29: 17-24. (In Galician)

Birgel, E.H., 1982. Hematologia clínica veterinária. In: Birgel, E.H. and F.J. Benesi, (Eds.), Patologia clínica veterinária. 1st Edn., Sociedade Paulista de Medicina Veterinária, São Paulo, pp: 2-34.

Castanheira, M., S.R. Paiva, H. Louvandini, A. Landim, M.C.S. Fiorvanti, G.R. Paludo, B.S. Dallago and C. McManus, 2010. Multivariate analysis for characteristics of heat tolerance in horses in Brazil. Trop. Anim. Health Prod., 42: 185-191.

Correa, M.P.C., M.T. Cardoso, M. Catanheira, A.V. Landim, B.S.L. Dallago, H. Louvandini and C. McManus, 2012. Heat tolerance in three genetic groups of lambs in central Brazil. Small Rumin. Res., 104: 70-77.

Cross, J.P., C.G. Mackintosh and J.F.T. Griffin, 1988. Effects of physical restraint and xylazine sedation on haematological values in red deer (*Cervus elaphus*). Res. Vet. Sci., 45: 281-286.

Cunninghan, J.G., 2004. Tratado de fisiologia veterinária. 3rd Edn., Guanabara Koogan, São Paulo.

El-Nouty, F.D., A. Al-Haidary and M.S. Salah, 1990. Seasonal variations in hematological values of high-and average-yielding Holstein cattle in semi-arid environment. J. King Saud Univ., 2: 173-182.

FNP Institute, 2010. Anualpec 2010. Agra FNP Pesquisas Ltd., São Paulo.

INMET, (Instituto Nacional de Metereologia), 2013. Banco de Dados Meteorológicos para Ensino e Pesquisa [*on line*]. Retreieved form: http://www.inmet.gov.br/portal/index.php?r=bdmep/bdmep.

Jain, N.C., 1993. Essentials of Veterinary Hematology. Lea e Febinger, Philadelphia.

Jones, M.L. and R.W. Allison, 2007. Evaluation of the ruminant complete blood cell count. Vet. Clin. Food Anim. Pract., 23: 377-402.

Kelly, C.F. and T.E. Bond, 1971. Bioclimatic Factors and their Measurement. In: Kelly, C.F. and T.E. Bond (Eds.), a Guide to Environmental Research on Animals. 1st Edn., National Academy of Sciences, Washington, pp: 7-92.

Marai, I.F.M., A.A. El-Darawany, A. Fadiel and M.A.M. Abdel-Hafez, 2007. Physiological traits as affected by heat stress in sheep: A review. Small Rumin. Res., 71: 1-12.

McManus, C., E.A. Dias, S.R. Paiva, J.B. Neto, J.A. Cobuci and H. Louvandini, 2011a. Os desafios da produção animal frente a mudanças climáticas. Vet. Zootec., (UNESP) 18: 142-148.

McManus, C., G.R. Paludo, H. Louvandini, R. Gugel, L.C.B. Sasaki and R.P. Paiva, 2009. Heat tolerance in Brazilian sheep: Physiological and blood parameters. Trop. Anim. Health Prod., 41: 95-101.

McManus, C., H. Louvandini, T.P. Paim, R.F.S. Martins, J.O.J. Barcellos, C.C. Cardoso, R.F. Guimarães and A.O. Santana, 2011b. The challenge of sheep farming in the tropics: Aspects related to heat tolerance. Braz. J. Anim. Sci., 40: 107-120.

McManus, C., S.R. Paiva and R.O. Araújo, 2010. Genetics and breeding of sheep in Brazil. Rev. Bras. Zootecn., 39: 236-246.

Menezes, A.M., H. Louvandini, G.I.F. Esteves, L. Dalcin, M.E.A. Canozzi, J.O.J. Barcellos and C.M. McManus, 2013. Performance and carcass traits of Santa Inês lambs finished with different sources of forage. Rev. Bras. Zootecn., 42: 428-437.

Morais, O.R., 2001. O melhoramento genético dos ovinos no Brasil. In: Pereira, J.C.C. (Ed.), Melhoramento genético aplicado à produção animal. 3rd Edn., Fepmuz, Belo Horizonte, pp: 320-330.

Neves, M.L.M.W., M. Azevedo, L.A.B. Costa, A. Guim, A.M. Leite and J.C. Chagas, 2009. Níveis críticos do índice de conforto térmico para ovinos da raça Santa Inês criados a pasto no agreste do Estado de Pernambuco. Acta Sci. Anim. Sci., 31: 169-175.

NRC (National Research Council), 1981. Effect of Environment on Nutrient Requirements of Domestic Animals. National Academy Press, Washington.

Paim, T., B.O. Borges, P.M.T. Lima, E.F. Gomes, B.S.L. Dallago, R. Fadel, A.M. Menezes, H. Louvandini, M.E.A. Canozzi, J.O.J. Barcellos and C. McManus, 2013. Thermographic evaluation of climatic conditions on lambs from different genetic groups. Int. J. Biometeorol., 57: 59-66.

Paiva, S.R., V.C. Silvério, A.A. Egito, C.M. McManus, D.A. Faria, A.S. Mariante, S.T.R. Castro, M.S.M. Albuquerque and J.A. Dergam, 2005. Genetic variability of the main Brazilian hair sheep breeds using RAPD-PCR markers and conservation implications. Pesqui. Agropecu. Bras., 40: 887-893.

Peinado, V.I., J.F. Celdrán and J. Palomeque, 1999. Basic haematological values in some wild ruminants in capitivity. Comp. Biochem. Physiol., 124: 199-203.

Ravagnolo, O. and I. Misztal, 2002. Effect of heat stress on no return rate in Holstein cows: Genetic analyses. J. Dairy Sci., 85: 3092-3100.

Ross, T.T., L. Goode and A.C. Linnerud, 1985. Effects of high ambient temperature on respiration rate, rectal temperature, fetal development and thyroid gland activity in tropical and temperate breeds of sheep. Theriogenology, 24: 259-269.

Scholtz, M.M., C. McManus, A.M. Okeyo, A. Theunissen, 2011. Opportunities for beef production in developing countries of the southern hemisphere. Livestock Sci., 142: 195-202.

Silva, R.G., 2000. Introdução à Bioclimatologia Animal. Nobel, São Paulo.

Thwaites, C.J., 1985. Physiological Responses and Productivity in Sheep. In: Yousef, M.K. (Eds.), Stress Physiology in Livestock. CRC Press, Boca Raton.