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Physiological and hematological parameters of sheep reared in the tropics and subtropics

[*Parâmetros fisiológicos e hematológicos de ovinos criados nos trópicos e nos subtrópicos*]

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ABSTRACT

This study aimed to determine the physiological and hematological parameters of sheep in Brazil. Therefore, 5,081 observations were used from previous experiments with animals from different Brazilian regions with the time of day, gender, breed, age, physiological characteristics, hematological and climatic variables. The animals were classified according to their stress level, and only data of non-stressed animals were used to calculate the reference values. Respiratory rate was the parameter that most differed from the normal range, with values above the limits usually reported for the species, being higher in commercial wool sheep. For hematological variables, differences were observed between the present results and the previously reported values in the literature. A higher number of red blood cells (RBC), lower hemoglobin and mean corpuscular hemoglobin concentration (MCHC) were observed in young animals. A higher number of RBC and MCHC were noted in sheep crossed with local breeds. Considering that physiological and hematological parameters are indicators of the animal's pathological or physiological state, for a correct interpretation of the results, the use of reference values based on animals with similar racial characteristics and subjected to similar environmental conditions is recommended.

Keywords: hematology, rectal temperature, reference interval, respiratory rate, small ruminants

RESUMO

O objetivo deste estudo foi determinar parâmetros fisiológicos e hematológicos de ovinos no Brasil. Portanto, foram utilizadas 5.081 observações de experimentos anteriores com animais de diversas regiões do Brasil, com diferentes horário, sexo, raça, idade, características fisiológicas, variáveis hematológicas e climáticas. Os animais foram classificados de acordo com o nível de estresse, e apenas os dados dos animais não estressados foram utilizados para o cálculo dos valores de referência. A frequência respiratória foi o parâmetro que mais diferiu em relação à normalidade, com valores acima dos limites usualmente relatados para a espécie, sendo maior em ovinos de lã comercial. Para as variáveis hematológicas, também foram verificadas diferenças entre os resultados observados e os valores previamente relatados na literatura. Maior número de hemácias, menor hemoglobina e concentração de hemoglobina corpuscular média (CHbCM) foram observados em animais jovens e maior número de hemácias e CHbCM em ovinos cruzados com raças locais. Considerando que os parâmetros fisiológicos e hematológicos são indicadores do estado patológico ou fisiológico do animal, para uma correta interpretação dos resultados recomenda-se a utilização de valores de referência baseados em animais com características raciais semelhantes e submetidos a condições ambientais também semelhantes.

Palavras-chave: frequência respiratória, hematologia, intervalo de referência, pequenos ruminantes, temperatura retal

INTRODUCTION

Changes in physiological parameters, biochemical and hematological constituents are important indicators of the animal's physiological or pathological state (Ahmad *et al*., 2003). For a correct interpretation of the results, it is necessary to consider the influence of regional factors, such as climatic and environmental conditions, breed and age (Jain, 1993). Researchers have reported an increase in some blood parameters such as the number of red blood cells and hemoglobin concentration with age development (David *et al*., 2012). Variation concerning genetic groups has also been reported (Correa *et al*., 2012). A study with Morada Nova sheep observed average red blood cell count values and hematocrit higher than those reported in the literature for small ruminants (Chaves *et al*., 2009).

The reference intervals are based on the values that occur in 95% of the healthy population (Vojta *et al*., 2011), and 5% of individuals may have blood count values outside the reference range. Therefore, small variations do not necessarily indicate any disturbance (Resende *et al*., 2013). A study carried out in Croatia found that the reference values used in the literature were inappropriate, and the calculation of specific confidence intervals for each geographical region is recommended (Šimpraga *et al*., 2013). Thus, the interpretation of the results depends on precise reference intervals that represent the studied population.

Considering that the reference values used are based on data from temperate animals and that animals in Brazil are subjected to environmental stressors different from those found in temperate regions, the use of reference tables with data from these regions may not be adequate to the Brazilian reality. Differences can also be seen between hair and wool sheep (McManus *et al*., 2020), and under climate change, the correct interpretation of these parameters is essential for animal management. Therefore, it is crucial to determine the standard parameters for non-stressed animals raised in the country, building a reference table with local data to make the comparison correctly. Thus, the present study aimed to define blood and physiological parameters for sheep in Brazil.

MATERIAL AND METHODS

A spreadsheet was prepared with 5,081 observations from previous trials carried out with sheep in the south, center-west and northeast regions (Rio Grande do Sul, Distrito Federal, Goiás and Rio Grande do Norte states) (Table 1). Data included the time of day, gender, breed, physiological, hematological characteristics and climatic variables (temperature and relative humidity). Based on climatic data, the Temperature and Humidity Index (THI) was calculated based on the equation below, where Tdb – is Dry Bulb Temperature and Twb – Wet Bulb temperature, according to Thom (1959):

$$THI = [0.4 \times (Tdb + Twb)] \times 1.8 + 32 + 15$$

The physiological and blood parameters evaluated were rectal temperature (RT), respiratory rate (RF), heart rate (HR), number of red blood cells (RBC), hematocrit (HT), hemoglobin concentration (HGB), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), number of white blood cell (WBC), monocytes (MONO), lymphocytes (LYM), eosinophils (EOSI), segmented neutrophils (SEGM), platelets (PLAT), total plasma protein (TPP), and fibrinogen (FIBRI). The animals were divided into groups by age: adult (equal to or over 365 days) and young (less than 365 days). Due to the variety of breeds, these were grouped into types: commercial wool (CW), local hair (LH) and crossed with hair (CH).

The animals were also classified according to the stress level, being considered THI stressor above 70 and non-stressful THI equal to or below 70 (Hahn *et al*., 2009). For the calculation of the means of the hematological and physiological parameters, only non-stressed animals were considered. Therefore, age and type factors were considered for the calculation. The analyses were performed using the statistical program SAS 9.3 (Statistical Analysis Institute, Cary, North Carolina) with a significance level of 5%. The PROC GLM was used fitting THI as a covariable, age group and sheep type as fixed effects, and experiment and locality as random effects.

Table 1. The number of trials carried out with sheep by type, breed and location (regions) in Brazil

Type	Breed	north east	center-west	south
Hair	Santa Inês		10	1
	Dorper		2	1
	Morada Nova	1	2	
Commercial Wool	Ile de France		3	2
	Texel		2	2
	Bergamacia		3	
	Hampshire Down		2	1
	Suffolk			2
	Corriedale			2
	Crioula Lanada			2
	Ideal			2
	Merino			1
	Romney Marsh			1
Crossbreds	Dorper x Santa Inês		2	
	Ile de France x Santa Inês		2	
	East Friesian x Santa Inês		2	
	Poll Dorset x Dorper		2	
	Poll Dorset x Santa Inês		2	
	Poll Dorset x White Dorper		1	
	Dorper x Santa Inês		2	
	Texel x Santa Inês		1	
	Texel x Dorper		2	

RESULTS

In general, although the means of the studied parameters are in agreement with the reference values, the values of the 2.5 and 97.5 percentiles that indicate the lower and upper limits, respectively, diverged from those pre-established in the literature (Jain, 1993; Reece and Swenson, 2004) (Tables 2 and 3). The respiratory rate was the parameter that most diverged from literature. All mean values and reference intervals well above the normal limits for the species in all types and age groups. Likewise, upper and lower heart rate limits were also not coincident with the reference values. In CW adults, the average heart rate was also higher than the intervals mentioned in the literature.

The maximum values for rectal temperatures of the adult CW and LH types and of all types of young sheep were also higher than the values considered normal. Regarding the erythrogram, the hematocrit's lower and upper limits were lower than the reference values (Jain, 1993), and the 2.5 percentile was outside the normal range. In general, the minimum values for the number of red blood cells and the concentration of hemoglobin of all types and age groups also differed from the reference values. In contrast, in young animals, the means of hemoglobin concentration of all types were lower than the reference interval.

Regarding the average qualitative characteristics, the maximum and minimum values of the MCV and MCHC of the adult LH sheep, and the average of the MCHC of the adult CH were different from the literature. In young animals, the mean as well as maximum and minimum limits of MCV and MCHC were lower than the normal ranges in all types. The total plasma protein values of the 2.5 and 97.5 percentiles of adult CH and LH types were lower and higher than the reference limits (Jain, 1993), respectively.

In the leukogram, there were also differences between the results and the values cited in the literature Although the average number of WBC was within the reference range, the maximum and minimum limits were divergent, with values below and above the pre-established limits being observed in all types and age groups, except for CH adults whose 2.5 percentile was higher.

Table 2. Least squares means of physiological and blood parameters for adult sheep (over one year old) in Brazil

	N	Mean	Standard Deviation	2.50%	97.50%	Reference Values*
CH						
RT	167	38.12	0.40	37.30	39.10	38.3-39.9°C
RR	167	67.44	49.24	20.00	204.00	20-34 mov.min⁻¹
HR	-	-	-	-	-	70-80 beats.min⁻¹
HT	167	29.35	5.99	16.00	40.00	27-45%
TPP	167	6.93	0.69	4.90	8.10	6-7.5g.dL⁻¹
RBC	167	8.65	1.69	5.41	11.55	9-15x10⁶.μL⁻¹
HGB	167	9.66	1.53	6.30	12.40	9-15g.dL⁻¹
WBC	167	9.32	3.17	5.00	15.10	4-12 x 10⁶.μL⁻¹
MONO	167	1168.40	2377.08	110.00	7500.00	0-750 10⁶.L⁻¹
LYM	167	2411.56	1194.70	988.00	5170	2000-9000 10⁶.L⁻¹
EOSI	167	1308.83	1896.35	201.00	7500	0-1000 10⁶.L⁻¹
SEGM	167	4980.11	2152.86	1700.00	10707	700-6000 10⁶.L⁻¹
PLAT	167	464.96	242.47	148.00	1031	250-750 x 10³.μL⁻¹
MCV	167	30.57	1.52	29.00	34	28-40fl
MCHC	167	37.43	7.90	30.00	57.71	31-34%
FIBRI	-	-	-	-	-	0.1-0.5g.dL⁻¹
CW						
RT	1337	39.50	0.70	38.00	40.7	38.3-39.90°C
RR	1337	81.40	44.66	24.00	192	20-34 mov.min⁻¹
HR	1337	113.51	47.21	64.00	272	70-80 beats.min⁻¹
HT	1337	30.78	4.98	22.00	40	27-45%
TPP	1337	7.52	0.74	6.40	9.2	6-7.5g.dL⁻¹
RBC	1337	8.81	1.32	6.19	11.2	9-15x10⁶.μL⁻¹
HGB	1337	9.70	1.45	6.70	12.5	9-15g.dL⁻¹
WBC	1337	8.75	3.14	2.16	14.6	4-12 x 10⁶.μL⁻¹
MONO	1337	1966.26	3046.14	104.00	9300	0-750 10⁶.L⁻¹
LYM	1337	3624.22	1396.91	1612	6555	2000-9000 10⁶.L⁻¹
EOSI	1337	1276.45	2058.44	110	8500	0-1000 10⁶.L⁻¹
SEGM	1337	5039.82	3585.93	1014	16456	700-6000 10⁶.L⁻¹
PLAT	1337	468.18	225.69	87	963	250-750 x 10³.μL⁻¹
MCV	1337	32.85	1.57	31	37	28-40fl
MCHC	1337	33.53	2.18	30	40.31	31-34%
FIBRI	-	-	-	-	-	0.1-0.5g.dL⁻¹
LH						
RT	1077	38.68	0.81	37.1	40.3	38.3-39.90°C
RR	1077	46.19	22.77	20	104	20-34 mov.min⁻¹
HR	1077	75.53	39.74	20	140	70-80 beats.min⁻¹
HT	1077	28.98	5.71	15	38	27-45%
TPP	1077	6.82	0.87	4.2	8.4	6-7.5g.dL⁻¹
RBC	1077	9.97	2.11	5.3	14.1	9-15x10⁶.μL⁻¹
HGB	1077	9.40	1.61	4.7	12	9-15g.dL⁻¹
WBC	1077	9.60	3.69	2.24	18	4-12 x 10⁶.μL⁻¹
MONO	1077	3234.33	3740.25	142	9300	0-750 10⁶.L⁻¹
LYM	1077	2781.17	1017.27	702	4557	2000-9000 10⁶.L⁻¹
EOSI	1077	368.06	246.62	142	1089	0-1000 10⁶.L⁻¹
SEGM	1077	4615.17	1177.99	3139	7560	700-6000 10⁶.L⁻¹
PLAT	1077	734.36	256.35	285	1280	250-750 x 10³.μL⁻¹
MCV	1077	33.05	5.99	23.52	48.19	28-40fl
MCHC	1077	32.09	4.41	25.7	41.19	31-34%
FIBRI	1077	0.35	0.17	0.1	0.68	0.1-0.5g.dL⁻¹

N = number of observations; CH = crossing with naturalized; CW = commercial wool; LH = local hair; RT = rectal temperature; RR = respiratory rate; HR = heart rate; HT = hematocrit; TPP = total plasma protein; RBC = red blood cells; HGB = hemoglobin; WBC = white blood cell; MONO = monocytes; LYM = lymphocytes; EOSI = eosinophils; SEGM = segmented; PLAT = platelets; MCV = mean corpuscular volume; MCHC = average globular hemoglobin concentration; FIBRI = fibrinogen; - = no data. *(Reece and Swenson, 2004); Jain (1993).

Table 3. Least squares means of physiological and blood parameters for young sheep (under one year old) in Brazil

	N	Mean	Standard Deviation	2.50%	97.50%	Reference Values*
CH						
RT	1040	39.35	0.66	38.09	40.5	38.3-39.9°C
RR	1040	70.37	51.91	20	176	20-34 mov.min⁻¹
HR	1040	74.40	12.81	56	108	70-80 beats.min⁻¹
HT	1040	28.10	3.66	20.5	33.8	27-45%
TPP	1040	6.00	0.23	5.8	6.2	6-7.5g.dL⁻¹
RBC	1040	11.80	1.42	9.16	14.26	9-15x10⁶.µL⁻¹
HGB	1040	8.13	1.32	5.8	9.8	9-15g.dL⁻¹
WBC	1040	7.47	2.54	3.44	13.6	4-12 x 10⁶.µL⁻¹
MONO	1040	1127.19	2212.82	100	8400	0-750 10⁶.L⁻¹
LYM	1040	2844.04	1198.34	930	5400	2000-9000 10⁶.L⁻¹
EOSI	1040	645.92	497.63	138	1904	0-1000 10⁶.L⁻¹
SEGM	1040	4166.43	3137.25	1040	16215	700-6000 10⁶.L⁻¹
PLAT	1040	196.13	68.42	134	349	250-750 x 10³.µL⁻¹
MCV	1040	23.74	1.57	21.3	26.3	28-40fl
MCHC	1040	29.00	2.11	26.8	33.5	31-34%
FIBRI	1040	0.32	0.16	0.1	0.6	0.1-0.5g.dL⁻¹
CW						
RT	545	39.67	0.67	38.29	40.6	38.3-39.9°C
RR	545	82.18	56.02	20	180	20-34 mov.min⁻¹
HR	545	72.92	14.39	56	120	70-80 beats.min⁻¹
HT	545	28.94	4.45	15.6	39.4	27-45%
TPP	545	-	-	-	-	6-7.5g.dL⁻¹
RBC	545	12.21	1.84	6.66	16.49	9-15x10⁶.µL⁻¹
HGB	545	8.53	1.46	4.5	10.8	9-15g.dL⁻¹
WBC	545	9.33	2.81	3.9	18.3	4-12 x 10⁶.µL⁻¹
MONO	545	1950.08	2846.29	100	8600	0-750 10⁶.L⁻¹
LYM	545	3500.65	1787.87	1287	7462.4	2000-9000 10⁶.L⁻¹
EOSI	545	1651.09	3046.22	273	14080	0-1000 10⁶.L⁻¹
SEGM	545	8644.04	14867.23	1989	66105	700-6000 10⁶.L⁻¹
PLAT	545	194.72	70.43	87	328	250-750 x 10³.µL⁻¹
MCV	545	23.70	1.51	21.3	26.6	28-40fl
MCHC	545	29.49	1.58	27.2	32.8	31-34%
FIBRI	545	0.37	0.24	0.1	0.8	0.1-0.5g.dL⁻¹
LH						
RT	915	39.20	1.04	36.7	40.5	38.3-39.9°C
RR	915	74.53	53.98	16	176	20-34 mov.min⁻¹
HR	915	74.63	16.39	60	120	70-80 beats.min⁻¹
HT	915	31.50	5.68	12.6	39	27-45%
TPP	-	-	-	-	-	6-7.5g.dL⁻¹
RBC	915	12.96	1.94	6.03	15.07	9-15x10⁶.µL⁻¹
HGB	915	8.96	1.50	3.5	11	9-15g.dL⁻¹
WBC	915	8.45	3.08	4.7	15.7	4-12 x 10⁶.µL⁻¹
MONO	915	389.83	220.43	158	942	0-750 10⁶.L⁻¹
LYM	915	3276.42	1266.41	940	4940	2000-9000 10⁶.L⁻¹
EOSI	915	766.42	459.73	188	1659	0-1000 10⁶.L⁻¹
SEGM	915	4334.58	1922.33	2013	8949	700-6000 10⁶.L⁻¹
PLAT	915	195.71	57.31	112	328	250-750 x 10³.µL⁻¹
MCV	915	23.88	1.15	20.9	25.9	28-40fl
MCHC	915	28.84	1.07	26.9	31	31-34%
FIBRI	915	0.38	0.19	0.2	0.6	0.1-0.5g.dL⁻¹

N = number of observations; CH = crossing with naturalized; CW = commercial wool; LH = local hair; RT = rectal temperature; RR = respiratory rate; HR = heart rate; HT = hematocrit; TPP = total plasma protein; RBC = red blood cells; HGB = hemoglobin; WBC = white blood cell; MONO = monocytes; LYM = lymphocytes; EOSI = eosinophils; SEGM = segmented; PLAT = platelets; MCV = mean corpuscular volume; MCHC = average globular hemoglobin concentration; FIBRI = fibrinogen; - = no data. *(Reece and Swenson, 2004); Jain (1993).

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The average number of monocytes was greater than the upper limit mentioned in the literature in all types and age groups. The same was observed for the number of eosinophils in adult and young adult and adult CH. In general, the means of the number of lymphocytes and segmented neutrophils were in accordance with the literature (Jain, 1993). However, the values of the 2.5 and 97.5 percentiles were different. As for the number of platelets, mean values were lower than the normal reported ranges in young animals.

There was a significant influence of type and age on physiological and hematological parameters (Tables 4 and 5). LH adult sheep had lower respiratory and heart rates, while higher rectal temperatures and respiratory rates were observed in CW animals. Regarding the difference between the age groups within each type, a higher rectal temperature was observed in young animals of all types and a higher respiratory rate in young LH.

The young LH sheep had a higher HT for the hematological parameters, with no significant difference being observed between adults. Higher numbers of red blood cells, lower concentration of hemoglobin and MCHC were found in young animals, and CH had a higher number of red blood cells and MCHC. MCV was higher in adults and the LH type. Still, concerning adults, they also had higher TPP, PLAT and FIBRI. As for the type, a higher TPP and PLAT were found in the CW and LH, respectively. In the leukogram analysis, the young CH sheep were those with the lowest WBC and the CWs the highest number of lymphocytes.

Table 4. Effect of the interaction between type and age for blood parameters on physiological and hematological parameters in sheep from Brazil

	CH	CW	LH
RT (°C)			
Adult	38.12bC	39.50bA	38.68bB
Young	39.35aB	39.67aA	39.20aB
RR (mov/min)			
Adult	67.44aB	81.4aA	46.19bC
Young	70.37aA	82.18aA	74.53aA
HR (beats/min)			
Adult	-	113.51aA	75.53aB
Young	74.395A	72.92bA	74.63bA
HT (%)			
Adult	29.35aA	30.78aA	28.98aA
Young	28.1aB	28.94aB	31.5aA
HGB (g.dL^{-1})			
Adult	9.66aA	9.70aA	9.40aA
Young	8.13bB	8.53bAB	8.96aA
MCHC (%)			
Adult	37.43aA	33.53aB	32.09aB
Young	29.00bA	29.49bA	28.84bA
WBC (x10^6.μL^{-1})			
Adult	9.32aA	8.74aA	9.60aA
Young	7.47bB	9.33aA	8.45aAB
PLAT (x10^3.μL^{-1})			
Adult	464.96aB	468.18aB	734.36aA
Young	196.13bA	194.72bA	195.71aA

Means with different letters differ from each other at 5% probability of error by the Tukey test. Capital letters in the line and small in the column. CH = crossing with naturalized; CW = commercial wool; LH = local hair; RT = rectal temperature (ºC); RR = respiratory rate (mov.min^{-1}); HR = heart rate (Beats.min^{-1}); HT = hematocrit (%); HGB = hemoglobin (g.dL^{-1}); WBC = white blood cells (10^6.μL^{-1}); PLAT = platelets (10^6.μL^{-1}); MCHC = average globular hemoglobin concentration (%); - = no data.

Table 5. Average blood parameters for the type and age of sheep from Brazil

Type	TPP	RBC	MONO	LYM	SEGM	EOSI	MCV	FIBRI
CH	6.80b	11.42a	1135.2a	2747.9b	4347a	800.9ab	24.57c	317.67a
CW	7.51a	10.43b	1961.5a	3593.3a	5941a	1375.5a	28.4979b	371.14a
LH	6.82b	10.12b	1970.1a	2979.3b	4503a	527.4b	32.5651a	350.23a
Age								
Adult	6.98a	9.84b	2047.3a	3281.6a	5272.3a	1118.8a	32.9624a	345.54a
Young	6.08b	12.08a	1238.4b	3055.6a	4959.1a	907.2a	23.7498b	340b

Means with different letters differ from each other at 5% probability of error by the Tukey test. CH = crossing with naturalized; CW = commercial wool; LH = local hair; TPP = total plasma protein (g.dL^{-1}); RBC = red blood cells; HGB = hemoglobin (g.dL^{-1}); MONO = monocytes (10^6.µL^{-1}); LYM = lymphocytes (10^6.µL^{-1}); EOSI = eosinophils (10^6.µL^{-1}); SEGM = segmented (10^6.µL^{-1}); MCV = mean corpuscular volume (fl); FIBRI = fibrinogen (g.dL^{-1}).

DISCUSSION

Blood parameters are used to assess animal health, as indicators of physiological changes, and influenced by factors such as species, gender, and age (Jain, 1993). Ribeiro *et al*., (2015) observed that the hematological parameters with greater power for discriminating two goat breeds' adaptive profile were the number of red blood cells, hematocrit and average corpuscular volume. Therefore, it is essential to determine precise reference intervals for these parameters to represent the studied population. As in the present study, Santana *et al*. (2009), when analyzing the complete blood count of young sheep, also found that the average values of the number of red blood cells were in accordance with the literature, and in both the minimum limit was lower than the "normal" range. Likewise, a study in Ceará with Morada Nova sheep observed that this parameter's mean was within the reference values (Chaves *et al*., 2009).

However, in this latter study, the intervals were not calculated. However, unlike the present study results, David *et al*. (2012) reported red cell averages in Santa Inês lambs below the normal range. It is worth mentioning that David *et al*. (2012) analyzed only animals from one location (west region of the state of São Paulo), while, in the present study, Santa Inês sheep from 11 trials located in the Midwest (Distrito Federal and Goiás) and the South (Rio Grande do Sul) were used. A divergence was observed concerning the average hemoglobin concentration in young animals, which is lower than the reference values. This corroborates with Correa *et al*. (2012) who also reported lower hemoglobin concentration in lambs and diverging from David *et al*. (2012) who observed averages of this parameter in young Santa Inês sheep in agreement with the literature.

The hematocrit means were within the confidence interval.

However, the minimum limits (2.5% percentile) were lower than this interval, similar to that verified by Santana *et al*. (2009). Likewise, hematocrit values have been reported in Santa Inês sheep outside the normal range for the species (Cardoso *et al*. 2011; David *et al*. 2012). Considering that, in sheep, hematocrit values below 24 are considered anemia (Polizopoulou, 2010), this difference between the results and the reference interval can lead to misdiagnosis.

In the present study, the number of red blood cells was higher in the younger rather than adult sheep, with the hemoglobin concentration being lower in this group and there was no significant difference for the hematocrit. This is in agreement with Yiğit *et al*. (2002), cited by Gama *et al*. (2007), who found that young sheep had higher mean values than adults for the number of red blood cells. As for the LH type, in which the Santa Inês breed is inserted, no significant difference was observed between the age groups for hemoglobin concentration and hematocrit. This corroborates in part with David *et al*. (2012). They also did not find any difference for the hematocrit in the sheep of this breed. Still, they reported a smaller number of red blood cells and hemoglobin concentration in the younger animals, suggesting an increase in blood parameters with age development. MCV averages were within normal limits. However, the maximum and minimum values of adult LH sheep were different from the literature. Chaves *et al*. (2009) and David *et al*. (2012) also observed mean MCV for naturalized sheep within the normal range, but these researchers did not check the upper and lower limits for this parameter.

Regarding the differences between the genetic types, the LH and CH animals had higher and lower CMV, respectively, corroborating with Correa *et al.* (2012) who reported lower MCV in animals crossed with Texel and higher in Santa Inês breed. Regarding age, CMV decreases with age development (Jain, 1993). However, in the present study, lower MCV was found in young animals, unlike David *et al.* (2012) who reported higher value in the younger age group.

Among the genetic types, higher rectal temperatures were observed in European origin animals compared with those naturalized or crossed with naturalized. This corroborates with Marai *et al.* (2007) who stated that animals adapted to hot climates showed less variation in the parameters due to racial morphological and physiological adaptations that help in the dissipation of excess heat. Unlike the findings of the present study, in which a significant difference was found for rectal temperature in the two age groups, Lima *et al.* (2010) found no difference with advancing age for crossbred animals with Dorper. However, these authors only analyzed young animals, from 1 to 90 days old, whereas young and adult animals were compared in the present study.

The increase in heart rate increases superficial blood circulation, aiding heat dissipation. Thus, an increase in this parameter indicates a greater need for heat loss (Correa *et al.*, 2012). In this study, this variable's mean was above the reference limits in adult CW sheep, and the maximum limits for all types and age groups were higher than usual standards. This is in agreement with McManus *et al.* (2009) who reported that even with mild temperatures during the morning, Santa Inês and Bergamascia sheep's heart rate was higher than 80 mov/min. In the present study, this parameter was lower in adult LH sheep, corroborating with Correa *et al.* (2012), who reported a lower rate in Santa Inês animals.

CONCLUSIONS

Our study shows divergence with the average hemoglobin concentration in young animals, which is lower than the reference values. The hematocrit means were within the confidence interval, but the minimum limits (2.5% percentile) were lower than this interval. Likewise, the hematocrit values have been reported in Santa

Inês sheep outside the species' normal range. The number of red blood cells was higher, and the hemoglobin concentration was lower in young sheep than adults. Also, we show the maximum and minimum values of adult LH sheep were different from the literature. Higher temperatures were observed in European origin animals compared with those that were naturalized or crossed with naturalized. Respiratory rate was the most diverged parameter, with the mean values and reference intervals well above the normal limits for the species in all types and age groups. Upper and lower heart rate limits were also not coincident with the reference values. In CW adults, the average heart rate was also higher than the intervals mentioned in the literature.

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