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Relationships between hot and cold seasons with blood biochemical indicators of Phan Rang sheep in Vietnam.

Bui Van Loi*[1,2], Nguyen Huu Van[2], Nguyen Xuan Ba[2], Nguyen Quang Linh[2]

[1]President Board, Hue University, 03 Le Loi St. Vinh Ninh, Hue City, Vietnam, 490000;

[2]Department of Animal Husbandry, Faculty of Animal Science and Veterinary Medicine, University of Agriculture and Forestry, Hue University, 102 Phung Hubg St., Dong Ba, Hue City, Vietnam 530000

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Bui Van Loi, bvloi@hueuni.edu.vn, Orcid: 0000-0002-4493-2703

Nguyen Huu Van, nguyenhuuvan@huaf.edu.vn,

Nguyen Xuan Ba, nguyenxuanba@huaf.edu.vn,

Nguyen Quang Linh, nguyenquanglinh@hueuni.edu.vn, Orcid: 0000-0002-8424-1148

*Corresponding author: Bui Van Loi, bvloi@hueuni.edu.vn

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Abstract

The study aimed to evaluate the influence of hot and cold seasons on the blood variables of Phan Rang sheep in Hue, Vietnam. The experiment was conducted on 24 sheep (01 to 36 months old). The results showed the number of red blood cells ranged from 6.58 - 7.79 million/mm3 (hot) and 7.24 - 8.82 million/mm3 (cold); haemoglobin, 7.04 - 8.64% and 8.23 - 9.67%; white blood cells, 7.60 - 8.71 thousand/mm3 and 8.00 - 9.06 thousand/mm3, $P < 0.05$, respectively. The hematocrit index ranged from 37.34 - 47.57% and 40.24 - 41.69%, with no significant difference between the two seasons, $P > 0.05$. The sheep were raised in high temperatures and humidity, the blood composition, RDW increased, mean platelet volume (MPV) and haemoglobin reduced (Hb - and MCH, respectively). MCH indicate the average, and MCHC shows the average haemoglobin weight based on red blood cell volume; MCH and MCHC were connected to breathing and ordinary respiration. Measurements for sheep are 25 to 30 breaths/minute. When the temperature increased to 39 – 40°C, the respiratory frequencies reached 35 – 38 breaths/minute, depending on the temperature change over 35oC and the breathing rate increased.

Keywords: Environmental conditions, blood variables, breathing, adaptation and health status

Introduction

The cattle body is a unified, complete mass interacting continuously with the living environment. Every change in the living environment directly affects the body's physiological responses. Sheep, like other livestock, are affected by many environmental factors; temperature and humidity are two factors that have a strong stimulating effect on the physiological state of the sheep's body, growth and reproduction (Bhatta et al., 2005; Srikandakumar et al., 2003). Recently, studies on the effects of temperature and humidity on sheep have received attention from many authors around the world, which has an impact on physiological indicators (Alhidary et al., 2012; Marai et al., 2009; McManus et 30. al., 2008; Bhatta et al., 2005). In Vietnam, there have not been many studies on the effects of temperature and humidity on sheep. Sheep have been introduced to our country for more than 100 years. Over time, they have adapted and developed well in Ninh Thuan - the southernmost region of Central Vietnam, with hot weather all year round, no cold season nd high air temperatures (dry season lasts 8-9 months, rainfall 717 mm; temperature 27.5 0C; humidity 79.9 %). Although the weight is not very large, few diseases grow well (Dinh Van Binh et al., 2007; Doan Duc Vu et al., 2004). Sheep in Phan Rang, Ninh Thuan, were brought to experimental farming in high humidity and heat conditions in Thua Thien Hue, with extremely harsh weather conditions, high annual rainfall (2,500 - 4,400 mm), temperature 20 – 25 0C, especially the air humidity is Consistent at 87 – 90 %, the temperature amplitude during the day is high. What physiological reactions do sheep have in new living conditions? To answer that question, we researched this topic.

Materials and methods

Materials and animals

The study was conducted on 24 sheep individuals at Thuy An Livestock Research Center, University of Agriculture and Forestry, Hue University (Center), Hue, Vietnam (in different age groups, from 1 month to 36 months old), each group of 4 sheep (2 males, two females). All the sheep were moved from Phan Rang, Ninh Thuan, Vietnam.

Feeding and animal care

Sheep are raised individually in separate pens, with members for monitoring; each pen is separated by iron bars, all cages are placed on a floor about 0.2 m above the ground, the floor has gaps to let dung fall to the ground, and the same row of houses are roofed with corrugated iron and have enough windows to ensure good ventilation. Airy. Each cage has separate roughage troughs, concentrate food troughs and drinking water troughs. During monitoring and determining blood biochemical indicators, sheep are kept entirely in captivity. They are only allowed to roam freely on Sundays to enable them to exercise and clean the barn. Sheep are provided with adequate food and water. Their forage is natural grass, elephant grass, rice straw, and leaves, supplemented with concentrates such as rice bran and corn flour. Before being included in the experimental monitoring for two months, sheep were separated with Albendazole 12 mg/1 kg P (Han-Dertil-B, Hanvet), administered orally into the sheep's bodies.

Research Variables and Methods

Data on temperature and humidity in sheep barns in Thua Thien Hue in the experiment were measured using an automatic hygrometer Hygro - Thermometer (France) at the

following time points: 1.00, 4.00; 7.00, 10.00, 13.00; 16.00; 19:00 and 22:00 h continuously every day of the month in two seasons: hot season (from June to August) and cold season (from December to February of the following year). The thermometer and hygrometer were placed nearly equal to the height of the adult sheep, 0.8m above the ground and 0.6m above the barn floor.

The temperature – humidity index (THI) was calculated according to Marai et al. (2000) using the modified formula:

$THI = T^0C - \{(0.31 - 0.31RH)(T^0C - 14.4)\}$

Where T^0C is the dry bulb temperature (^0C) and RH is the relative humidity (RH/100). The values obtained indicate the following: <22.2=absence of heat stress; 22.2 to <23.3=moderate heat stress: 23.3 to <25.6 = severe heat and 25.6 and more = extreme severe heat tress (Marai et al. 2000).

Blood variables and respiratory rates

Blood biochemical indicators such as red blood cells, white blood cells, haemoglobin and hematocrit, Mean Corpuscular Hemoglobin (MCH): Average amount of haemoglobin in a single RBC; Mean Corpuscular Hemoglobin Concentration (MCHC): Average concentration of haemoglobin in a single red blood cell; Red Cell Distribution Width (RDS): The variation in the size of red blood cells are taken and determined according to the months of the year, through two seasons: hot and cold. Blood was collected on the 27th day of each month. Blood was collected from the sheep's jugular vein early in the morning before the animal was fed and exercised. Each time, take 1ml of blood and put it in a test tube containing Sodium citrate anticoagulant, then shake it well, put it in a foam box, and transport it to the Department of Hematology, University of Medicine and Pharmacy, Hue University for analysis. The number of red blood cells, white blood cells, haemoglobin and hematocrit were determined using an automatic cell counter SYSMEX KX 21 (made in Japan). Before veined for blood samples, breath rates were determined.

Data analysis

Collected data were managed with Microsoft Excel software and processed with descriptive statistics and analysis of variance (ANOVA) on Minitab software. Compare the Tukey method's mean difference between treatments with a 95% confidence interval.

Results

Housing temperature and humidity

Based on annual temperature and humidity variations, Thua Thien Hue is divided into two distinct seasons: the hot season from June to August each year and the cold season from December to February the following year. Temperature and humidity data in the hot and cold seasons are compiled and averaged. Table 3.1 shows sheep barns' temperature and humidity differ between hot and cold seasons. The temperature in the hot season (average 30,60 ^0C) is 5,38 ^0C higher than the cold season (average 25,22 ^0C). Humidity has the opposite trend; humidity in the hot season (average 73.31 %) is 15.59 % lower than in the cold season (88.90 %). Notably, the temperature is always high over the months, > 30.29 ^0C in the hot season, but the humidity is still high, >71.93 %. This leads to difficulties in sheep discharging heat, primarily through the skin. Sheep are at risk of heat stress during hot seasons. In the cold season, the temperature in Thua Thien Hue is relatively low, an average of 25,22^0C, compared to the annual average temperature in Ninh Thuan, where Phan Rang

sheep have performed well at 26 - 27°C. The humidity is high, an average of 88.90%, compared to 78% for Ninh Thuan, so there is a risk that the sheep may be exposed to cold stress. The results are summarised and processed statistically, shown as follows (Table 3.1).

Table 3.1. *Housing temperature and humidity in hot and cold seasons*

Seasons	Hot					Cold				
	n	June	July	August	Ave.	n	Dec.	Jan	Feb	Ave.
Tem.	736	31.16	30.35	30.29	**30.60**	720	24.15	23.68	27.83	**25.22**
Hum.	736	69.51	71.93	72.48	**73.31**	720	92.44	91.04	83.22	**88.90**
THI	736	27.55	26.79	26.72	**26.92**	720	21.36	21.06	24.37	**22.24**

Relationships of blood variables between hot and cold seasons

Table 3.2 shows the number of red blood cells of Phan Rang sheep in different age groups during the hot and cold seasons in Thua Thien Hue. Results in Table 3.2 show that the number of red blood cells in sheep raised in Thua Thien Hue at different ages differs between the hot and cold seasons (P>0.05). Specifically, the number of red blood cells in sheep in the cold season is higher than in the hot season at all ages. In this study, red blood cells ranged from 6.58 - 7.79 million/mm^3 (hot season) and 7.24 - 8.82 million/mm^3 (cold season). The results of many domestic studies on the Phan Rang sheep breed show that the number of red blood cells in Phan Rang sheep ranges from 9.49 to 10.23 million/mm^3 (Dinh Van Binh et al., 2007; Tran Quang Han, 2007) and higher than the results of the current study. Soliman et al. (2012) and Jelineks and CS (1986) said that sheep red blood cells fluctuate considerably (6.5-10.3 million/mm^3 of blood).

Table 3.2. *Relationships between Hot, Cold and Erythrocytes (Mil/mm^3)*

Age group	Hot		Cold		P
	n	M ± SE	n	M ± SE	
01 - 06 months	7	7.79 ± 0.81	10	8.82 ± 0.86	0.025
07 – 09 months	16	6.58 ± 0.62	12	7.24 ± 0.91	0.032
10 – 12 months	16	6.58 ± 0.65	10	7.40 ± 1.20	0.031
> 12 months	12	6.60 ± 0.70	20	7.42 ± 1.19	0.028

n: Number of sheep, M: mean value, SE: Standard error

Feeding conditions and care regimen, the number of red blood cells in sheep has differences between the hot and cold seasons (P>0.05) (table 3.2). The number of red blood cells in sheep in the cold season is higher than in the hot season at all ages. This difference in sheep's red blood cell count is consistent with previous studies.

Relationship of hot and cold seasons with haemoglobin content

The haemoglobin content of Phan Rang sheep in different age groups through the hot and cold seasons in Thua Thien Hue is shown in Table 3.3. The study's haemoglobin content of Phan Rang sheep was 7.04 - 8.64% (hot season) and 8.23 - 9.67% (cold season), according to the research results of Dinh Van Binh and CS. (2007), the haemoglobin content of Phan Rang sheep raised in Ba Vi is 7.3g%.

Table 3.3. *Relationships between Hot, Cold and haemoglobin (%)*

Age groups	Hot		Cold		P
	n	M ± SE	n	M ± SE	
01 - 06 months	7	8.64** ± 0.50	10	9.67 ± 0.71	0.005
07 – 09 months	16	7.35* ± 1.00	12	8.23 ± 0.91	0.033
10 – 12 months	16	7.17***±0.86	10	8.46 ± 0.77	0.001
> 12 months	12	7.04** ± 1.24	20	8.56 ± 1.30	0.002

n: Number of sheep, M: mean value, SE: Standard errors

Relationship of hot and cold seasons with hematocrit content

Table 3.4 shows the hematocrit content of Phan Rang sheep in different age groups during the hot and cold seasons in Thua Thien Hue. The hematocrit index of sheep ranges from 37.34 - 47.57% (hot season) and 40.24 - 41.69% (cold season). This result is higher than previous publications (McManus et al., 2008; Piccione et al., 2008; Tran Quang Han, 2007; Jelíneks et al., 1986). Data from studies fluctuate from 24.14 to 34.8%. Tran Quang Han (2007) said that the hematocrit index of sheep raised in Dak Lak is 34.54-34.8%. However, this result is consistent with the recommendations of Ullrey et al. (1965). According to Ullrey et al. (1965), the hematocrit index of sheep varied widely from 27.2 to 41.9%. Studies show ambient temperature and humidity during the day do not affect sheep's hematocrit content—research results of McManus and CS. (2008), Bhattacharya and Uwayjan (1975), although there were significant changes in temperature and humidity in the morning and afternoon, the hematocrit content of Awasi sheep did not differ.

Table 3.4. *Relationships between Hot, Cold and hematocrit (%)*

Age Group	Hot		Cold		P
	n	M ± SE	n	M ± SE	
01 - 06 months	7	47.57*±19.26	10	41.69 ± 15.07	0.490
07 – 09 months	16	37.34*±16.20	12	40.24 ± 15.80	0.469
10 – 12 months	16	38.26 ± 17.46	10	41.08 ± 12.78	0.675
> 12 months	12	43.41 ± 22.22	20	40.35 ± 12.82	0.636

n: number of sheep, M: mean value, SE: Standard error

Relationship of hot and cold seasons with white blood cell count

Table 3.5 shows the number of white blood cells of Phan Rang sheep in different age groups during the hot and cold seasons in Thua Thien Hue. The number of white blood cells in the study showed no difference between hot and cold seasons for sheep groups 01 - 06 months, 10 - 12 months, and over 12 months ($p>0.05$). But there is a difference in sheep at 07 - 09 months ($p<0.05$). This is consistent with previous recommendations.

Table 3.5. *Relationships between Hot, Cold and blood white Cell (thousand/mm³)*

Age group	Hot		Cold		P
	n	M ± SE	n	M ± SE	
01 - 06 months	7	8.54± 0.48	10	9.06 ± 0.68	0.105
07 – 09 months	16	7.63* ± 0.93	12	8.68 ± 1.66	0.042
10 – 12 months	16	7.60 ± 1.37	10	8.00 ± 2.05	0.585
> 12 months	12	8.71 ± 2.34	20	8.40 ± 2.98	0.759

n: sheep numbers, M: mean value, SE: standard errors.

White blood cells range from 7.60 to 8.71 thousand/mm³ (hot season) and 8.00 to 9.06 thousand/mm³ (cold season). This result is within the limits of similar studies in our country (Dinh Van Binh et al., 2007; Tran Quang Han, 2007). The authors said that the number of white blood cells of sheep raised in Ba Vi and Dak Lak ranges from 8.01 to 9.5 thousand/mm³. However, research results on Awali sheep were lower (4.1-6.2 thousand/mm³) (Bhattacharya and Uwayjan, 1975), and on sheep in Brazil were higher (11.77-14.77 thousand/mm³). (McManus et al., 2008); West African Dwarf sheep is 15.35 - 15.54 thousand/mm³ (Olayemi et al., 2000). This difference may be due to breed differences. Blood physiological indicators (red blood cells, haemoglobin, hematocrit and white blood cells) of sheep raised in temperature and humidity conditions in hot and cold seasons in Thua Thien Hue, although fluctuating, are still within limits. Normal blood physiology of sheep breeds. This result can again conclude that the Phan Rang sheep breed can adapt to environmental conditions in Thua Thien Hue.

Table 3.6. *Relationships between hot and cold seasons with blood white cells (%)*

Age group	Hot		Cold		P
	N	M ± SE	N	M ± SE	
Neutrophil (WBC) (%)					
01 - 06 months	7	58.00 ± 1.83	10	62.25 ± 5.74	0.208
07 – 09 months	16	48.88* ± 5.70	12	54.50 ± 5.73	0.016
10 – 12 months	16	50.19** ± 3.62	10	54.30 ± 5.53	0.009
> 12 months	12	48.00* ± 2.86	20	51.64 ± 5.97	0.066
Acids (WBC) (%)					
01 - 06 months	7	17.00 ± 1.83	10	15.25 ± 1.98	0.232
07 – 09 months	16	15.63 ± 4.11	12	15.42 ± 4.32	0.898
10 – 12 months	16	14.31 ± 3.16	10	13.80 ± 2.90	0.682
> 12 months	12	13.75 ± 2.53	20	13.93 ± 2.73	0.865
Mono (WBC) (%)					
01 - 06 months	7	6.50 ± 1.29	10	9.75 ± 1.71	0.023
07 – 09 months	16	4.00 ± 3.25	12	5.17 ± 3.56	0.375
10 – 12 months	16	4.31 ± 2.75	10	6.00 ± 2.63	0.135
> 12 months	12	3.58 ± 2.78	20	4.43 ± 2.38	0.411
Lympo (WBC) (%)					
01 - 06 months	7	18.50* ± 1.29	10	12.75 ± 4.43	0.047
07 – 09 months	16	32.75 ± 11.56	12	24.92 ± 11.07	0.082
10 – 12 months	16	31.19 ± 8.63	10	25.90 ± 5.13	0.093
> 12 months	12	34.67 ± 6.73	20	30.00 ± 5.71	0.068
MCV (fl)					

01 - 06 months	7	53.05 ± 13.98	10	65.95 ± 13.98	0.536
07 – 09 months	16	59.09 ± 7.31	12	71.97 ± 9.23	0.289
10 – 12 months	16	54.36* ± 6.40	10	77.21 ± 8.34	0.039
> 12 months	12	65.51 ± 8.14	20	79.84 ± 7.53	0.209
MCH (Unit (picogram, pg))					
01 - 06 months	7	13.05 ± 0.65	10	14.30 ± 0.65	0.223
07 – 09 months	16	11.09* ± 0.46	12	12.68 ± 0.58	0.041
10 – 12 months	16	10.76 ± 0.37	10	11.51 ± 0.48	0.230
> 12 months	12	10.26*** ± 0.45	20	12.75 ± 0.42	0.000
MCHC (g/l)					
01 - 06 months	7	283.75 ± 33.65	10	358.75±33.65	0.166
07 – 09 months	16	208.44**± 15.80	12	274.40±19.99	0.016
10 – 12 months	16	232.19 ±22.14	10	226.40±18.26	0.875
> 12 months	12	192.75***±22.66	20	304.93±20.98	0.001
RDSW (%)					
01 - 06 months	7	17.00 ± 0.33	10	18.20 ± 0.33	0.041
07 – 09 months	16	18.05 ± 0.28	12	18.58 ± 0.36	0.256
10 – 12 months	16	17.95 ± 0.25	10	18.26 ± 0.33	0.458
> 12 months	12	16.92*** ± 0.28	20	18.94 ± 0.26	0.000
PLT (× 10^3/mcL)					
01 - 06 months	7	835.00 ± 47.16	10	762.50±47.16	0.319
07 – 09 months	16	821.88***±18.69	12	642.30±23.65	0.000
10 – 12 months	16	847.35** ± 23.78	10	727.60±30.99	0.005
> 12 months	12	838.75** ± 26.93	20	721.43±24.94	0.004

n: numbers of sheep, M: mean value, SE: standard errors

The Blood White Cells

The sheep Phan Rang's lymphocytes and monocytes of white cells were changed in different seasons, such as hot and cold weather, as shown in Table 3.6 below. The MCH, MCHC, and platelets were changed to reduce sheep's older and freezing conditions. This will be related to sheep's breath adapted to hot conditions, as Table 3.7 shows. The status of sheep and data concerning RBC have been investigated in sheep and determined. So, sheep RBCs are somewhat more significant than most mammalian RBCs [2]; they have a diameter of 4.5 µm, a width of 3.2–5 µm and a lifespan of 70–150 days, they do not aggregate or deform as readily as RBCs of other non-ruminant species [3,10]. This study's mean and standard error values for RBC length and breadth were 16.51 ± 0.47 and 18.31 ± 0.42 µm, respectively. A minor difference in the values of the mentioned morphometric parameters in this study compared to Adili et al. [3,10] is likely related to the different ovine breeds and breeding methods. Breed, age, and sex are known to affect the values of morphometric parameters [11,24]. In our study, although in a different sheep breed, the RBC length/diameter values are almost equal to those of Thamer et al. [25] (5.277 ± 0.67 µm). The RBC area value obtained in this study (21.19 ± 3.45 µm2) does not match the values reported by Adili et al. [2], whose values of RBC circumference (16.89 ± 0.72 µm) and area (16.49 ± 0.97 µm2), obtained from both ewes and rams, were almost equal, which is surprising. In this research, the differences in the mean values of RBC morphometric size and shape parameters were determined between groups formed by categorisation of haematological parameters values (HGB, HCT, MCV, MCH, MCHC, and RDW) in Phan Rang

sheep. In addition, significantly higher values of RBC area, outline, convex, minimal radius, maximal radius, length, and breadth were established in the groups with higher vs. the groups with lower values of HGB, HCT, MCV, MCH, and MCHC, respectively. The results of the RBC morphometric size parameters determined in this study are consistent with those of Ravi Sarma [26], who stated that higher red cell MCH and MCHC values are invested and increased.

Table 3.7. *Mean Breathing rates of different environmental conditions at different THI*

THI	T°C	RH (%)	Standing		Lying	
			N	M ± SE (BR/Min.)	N	M ± SE (BR/Min.)
24.74	25	92	12	16.15 ± 3.07	20	16.25 ± 2.07
25.71	26	92	7	17.12 ± 3.11	10	17.33 ± 2.11
26.61	27	90	16	17.66 ± 3.09	12	17.77 ± 2.09
27.28	28	83	16	17.69 ± 3.21	10	17.89 ± 3.21
28.23	29	83	12	18.11 ± 4.33	20	18.55 ± 3.33
29.23	30	84	7	18.56 ± 3.55	10	18.56 ± 3.55
29.97	31	80	16	18.99 ± 4.77	12	18.77 ± 3.77
30.85	32	79	16	19.25 ± 3.22	10	18.21 ± 3.22
31.50	33	74	12	20.15 ± 3.25	20	20.22 ± 3.25
32.18	34	70	7	20.34 ± 4.14	10	20.34 ± 4.14
33.34	35	74	16	22.15 ± 3.88	12	20.15 ± 4.88
34.19	36	73	16	25.88 ± 3.56	10	22,16 ± 4.56
35.04	37	72	12	29.33 ± 3.52	12	25.17 ± 4.52
36.02	38	73	7	35.77 ± 5.21	7	27.24 ± 5.12
36.86	39	72	16	38.72 ± 5.67	16	28.44 ± 5.21
36.43	40	70	12	39.15 ± 5.33	12	29.77 ± 6.33

Abbreviation, THI: Temperature–Humidity Index; T: Temperature; RH: relative humidity; N: number of Breathing rates; BR: Breathing rates; M: mean value; SE: standard errors.

Discussion

This is an issue that needs to be kept in mind when raising sheep in the weather conditions in Thua Thien Hue. Thus, the temperature and humidity in Thua Thien Hue differ between the hot and cold seasons compared to Ninh Thuan, which is characterised by a hot and dry climate, with temperatures consistently high and humid. A low altitude throughout the year - where sheep have been raised, survived, thrived and adapted here for hundreds of years. In that climate, Thua Thien Hue's climate has the general characteristics of a cold season: cold - humid and hot season: sunny – hot. To evaluate the adaptability of Phan Rang sheep in environmental conditions in Thua Thien Hue, sheep's blood physiological indicators were collected and analysed on 24 Phan Rang sheep raised in poor conditions, the hot and cold season environments with different age housing groups. This difference may be due to the nutritional diet of sheep in different farming methods. Sheep in this study fed mainly on natural grass and roughage such as straw, jackfruit leaves, and elm leaves, and supplemented concentrates were very limited. Previous studies also showed that the number of red blood cells in sheep depends on nutrition (Binev et al., 2006; Olayemi et al., 2000). According to Binev et al. (2006), red blood cells of Ile de France sheep when fed a limited diet were 7.79 million/mm3; when fed a diet with high energy and protein levels were 9.74 million/mm^3. Sheep red blood cells in intensive farming conditions are 8.17 million/mm^3, and in extensive farming conditions are 7.92 million/mm^3 (Olayemi

et al., 2000); Kajli sheep red blood cells are 7.20 - 10.60 million/mm^3 (Saddiqi et al., 2011), Niamey sheep red blood cells are 7.9 - 8.4 million/mm^3 (Al-Haidary, 2004). Thus, the number of red blood cells in sheep's blood raised under environmental conditions in Thua Thien Hue is within the normal physiological range of the sheep breed. Studies show that the number of red blood cells in sheep varies according to the year's seasons (Fadare et al., 2012). According to Fadare et al. (2012), at the end of the dry season in Nigeria, the red blood cell count of West African Dwarf sheep was higher than at the beginning of the rainy season. However, the author also said that the correlation between the number of red blood cells and environmental temperature and humidity is not tight. The number of red blood cells does not vary according to the time of day (McManus et al., 2008; Bhattacharya and Uwayjan, 1975). According to Bhattacharya and Uwayjan (1975), although there are significant changes in temperature and humidity in the morning and afternoon, Awasi sheep's red blood cells still have no difference. Sheep red blood cells in the morning are 10.54 million/mm^3, and in the afternoon, are 10.04 million/mm^3 (McManus et al., 2008). Previous data also show that haemoglobin content has a significant fluctuation of 6.19 - 13.53g% (Saddiqi et al., 2011; Srikandakumar et al., 2003; Olayemi et al., 2000). The haemoglobin content of Omani sheep is 13.43 - 13.53g%, and Merino sheep is 10.53-12.65g% (Srikandakumar et al., 2003); Santa Ines and Bergamasca sheep (Brazil) is 9.12 - 9.16g% (McManus et al., 2008); Belice sheep (Italy) is 8.98g% (Piccione et al., 2008); Naimey sheep is 11.04 – 11.4 g% (Al-Haidary, 2004); West African Dwarf sheep in intensive farming conditions is 7.38g% and in extensive farming conditions is 6.19g% (Olayemi et al., 2000). This research result is consistent with previous studies (Fadare et al., 2012; McManus et al., 2008; Srikandakumar et al., 2003; Bhattacharya and Uwayjan, 1975). Srikandakumar and CS. (2003) said that the haemoglobin content of Merino sheep (Australia) in the cold season is 12.65 g%, while in the hot season, it is 10.53 g%. According to Srikandakumar et al. (2003), the Hb of Merino and Omani sheep in the cold season is 12.65 g/dl and 13.43g/dl; In the hot season, it is 10.53g/dl and 13.53g/dl. Research results of McManus and CS. (2008), Bhattacharya and Uwayjan (1975) showed no difference in sheep's Hb content in the morning and afternoon. Thus, the assessment results of haemoglobin content in this study are within the normal physiological state. The authors showed that sheep's white blood cell count has seasonal differences (Fadare et al., 2012) and time of day (McManus et al., 2008; Bhattacharya and Uwayjan, 1975). According to Fadare et al. (2012), at the end of the dry season in Nigeria, the leukocytes of West African Dwarf sheep were lower than at the beginning of the wet season. Sheep's white blood cells in the morning are 4.1 thousand/mm3, increasing in the afternoon to 6.2 thousand/mm3 (Bhattacharya and Uwayjan, 1975). The above analysis results show that the number of red blood cells, haemoglobin content, and white blood cell count (age group 07 - 09 months) are different between the hot and cold seasons (P>0.05). The hematocrit index and white blood cell count at 01 - 06 months, 10 - 12 months, and over 12 months were not statistically different between the two seasons (P>0.05). The difference may be due to low temperature and high humidity during the cold season, which increases metabolism. Heat exchange, especially, increases the number of red blood cells and haemoglobin content. The body temperature is generally considered a good index of deep body temperature even though there is considerable variation in different conditions (hot and cold) of the deep body core at other times of the day. The higher magnitude of increase in body temperature in Phan Rang sheep during heat stress suggests that these animals can store body heat during periods of heat stress. This can economise on the loss of water and the increased energy need associated with increased (Blaxter, K. L., et al., 1059a). When both the young and older sheep were

subjected to heat stress, especially a high temperature, they could still maintain an ordinary acid–base increased when their respiratory rates and body temperature were significantly elevated, $P < 0.05$. In addition, there were significant changes in the blood MCH and MCHC due to heat stress, but they were within the normal physiological limits (Duncan and Prasse, 1994). The lower magnitude of changes in respiratory rate along with the ability of Phan Rang sheep to store body heat during periods of lower temperature increased by a high THI as a high temperature up to 39 – 40°C and humidity 90 – 92%, as shown in Table 3.7. Among the heat tolerance indices, the RR (respiratory rate) is the only one that is considered a variable. The direct relationship between this index and physiological parameters such as RR and MCH, MCHC indicates that sheep with a lower RR and MCH, MCHC are considered more adapted. The RR was lower for sheep in cold conditions but at lower humidity, indicating better adaptability. Phan Rang sheep were also considered more adapted than other sheep according to the Iberia index, which was higher for Phan Rang sheep. The blood variables of Phan Rang sheep raised in Hue have more adaptation by changing blood composition, increasing MCH and MCHC, even RDSW, and decreasing breathing rates for body temperature by increasing. Observation of blood physiological indicators and body physiological activities of Phan Rang sheep raised in temperature and humidity conditions in Hue shows that they are well-adapted to hot and humid conditions.

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No conflicts of interest

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Data availability statement

All data and materials are available in the manuscript.

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