Physiological and Biochemical Profile of Housed Hu Sheep in the Zizhong Area of Sichuan Province in Autumn

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Abstract [**Objectives**] This study was conducted to investigate the physiological and blood physiological and biochemical indicator characteristics of Hu sheep raised in the Zizhong area of Sichuan Province in autumn. [**Methods**] Ten adult male and ten adult female Hu sheep were selected as research subjects, and their physiological indicators as well as blood physiological and biochemical indicators were determined. [**Results**] The body temperature of rams was significantly higher than that of ewes ($P < 0.05$), while the heart rate of ewes was significantly higher than that of rams ($P < 0.05$). No significant difference was observed in respiratory rate between rams and ewes ($P > 0.05$). Eleven blood physiological indicators, including total white blood cell count, total red blood cell count, total platelet count, lymphocyte count, and hemoglobin content, showed no significant differences between rams and ewes ($P > 0.05$). The creatinine content in rams was significantly higher than that in ewes ($P < 0.05$), while the urea nitrogen/creatinine ratio in ewes was significantly higher than that in rams ($P < 0.05$). Fourteen blood biochemical indicators, including glucose, alanine aminotransferase, alkaline phosphatase, total protein, and albumin, showed no significant differences between rams and ewes ($P > 0.05$). [**Conclusions**] The indicators of housed Hu sheep in autumn in the Zizhong area were generally within normal physiological ranges, providing support for healthy breeding and physiological adaptability of Hu sheep in this area.

Key words Physiological parameter; Biochemical parameter; Hu sheep; Respiratory rate; Heart rate; Temperature
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Animal blood flows to various organs and tissues throughout the body via the circulatory system, performing multiple functions such as material transport, buffering, defense, and regulation within the organism. It participates in physiological activities including respiration, nutrient transportation, and the regulation of acid-base balance in animals. The physicochemical indicators in livestock blood reflect the health status of the organism and are commonly used to evaluate feeding management[1-2], diagnose diseases[3-4], and assess regional adaptability[5], among other applications. In recent years, Hu sheep have been widely introduced to regions such as Gansu, Xinjiang, Sichuan, and Hunan for breeding or crossbreeding with local breeds due to their excellent characteristics, including rapid early growth rate, multiple births and multiple lambs, and year-round estrus. Their adaptability to new environments is typically assessed using physiological indicators and blood physiological and biochemical parameters.

Hu sheep are a precious genetic resource of livestock and poultry in China. They are favored by farmers and enterprises for their characteristics such as rapid early growth and development, year-round estrus, strong adaptability, multiple births and multiple lambs, and good lactation performance. Consequently, they have become a livestock breed with significant promotion value in the transformation and upgrading of agricultural modernization. Located in the inland region of Southwest China, Sichuan Province has a diverse range of climate types, with most areas featuring a humid subtropical climate characterized by relatively high temperatures, high humidity, and abundant rainfall. The province boasts abundant agricultural resources, with ample feed resources such as straw and forage, providing the basic material conditions for the introduction and breeding of Hu sheep in the Sichuan region. Furthermore, the robust mutton consumption market in Sichuan, coupled with the continuously growing demand for mutton, provides a broad consumer market for the development of the meat sheep industry.

Zizhong County is located in the central part of the Sichuan Basin, with a latitude of 29°34′-30°24′ N and a longitude of 104°27′-105°07′ E. It has a humid subtropical monsoon climate with distinct seasons, mild temperatures, abundant rainfall, early spring, long summer, and short autumn and winter. The area experiences neither intense heat in summer nor severe cold in winter, and has a long frost-free period. The area boasts abundant agricultural resources, with ample feed resources such as straw and forage, providing a material foundation for the development of housed sheep farming. To determine whether Hu sheep introduced to the Zizhong area are adapted to the local climate, environment, and forage, it is necessary to assess their physiological health status. In this study, Hu sheep that had been acclimatized and raised for over one year in the Zizhong area of Sichuan Province were selected as research objects, and their physiological and blood physiological and biochemical parameters were measured in autumn to investigate whether they had successfully adapted to the climatic conditions, environment, and feed resource in this area.

Materials and Methods

Experimental animals

The study focused on Hu sheep introduced to and raised in the Zizhong area of Sichuan Province. A total of 20 healthy adult

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sheep, consisting of 10 males and 10 females aged 3 to 5 years, were selected. All animals had been raised in this area for at least one year. They were housed and fed with free access to water.

Physiological indicators

In October 2022, between 6:00 and 8:00 a.m., the rectal temperature, heart rate, and respiratory rate of both male and female Hu sheep were measured. The measurement was conducted in a quiet environment, ensuring the restrained sheep remained as calm as possible.

Blood sample collection

Blood samples (6 – 8 ml) were collected from the jugular vein of fasting Hu sheep in the morning using a syringe. Approximately 3 – 4 ml of the blood was injected into a 5 ml EP tube containing EDTA-K2 as an anticoagulant and gently inverted to mix thoroughly. The remaining blood was injected into another EP tube without anticoagulant and allowed to coagulate naturally. The collected samples were stored at 4 ℃ and promptly transported to Shuangliu County Aixin Animal Hospital for analysis of blood physiological and biochemical parameters.

Statistical analysis

Statistical analysis of the obtained data was performed using IBM SPSS Statistics 22. The results were expressed as mean ± standard deviation ($\bar{x} \pm S$).

Results and Analysis

Physiological indicators

As shown in Table 1, after a period of adaptation to the Zizhong area in Sichuan Province, the body temperatures of male and female Hu sheep in autumn were (39.71 ± 0.29) and (39.19 ± 0.21) ℃, respectively. The body temperature of rams was significantly higher than that of ewes ($P < 0.05$), but both remained within the normal physiological range for sheep. The respiratory rates were (36.30 ± 2.45) breaths/min for rams and (35.30 ± 3.31) breaths/min for ewes, with no significant difference between sexes ($P > 0.05$). The heart rates were (80.50 ± 7.66) beats/min for rams and (90.50 ± 9.05) beats/min for ewes, showing a significantly higher heart rate in ewes than in rams ($P < 0.05$).

Blood physiological indicators

As shown in Table 2, for the housed Hu sheep in the Zizhong area, the following blood physiological indicators were recorded for rams and ewes, respectively: total white blood cell count, (227.99 ± 23.20) × 10^9/L and (242.54 ± 24.48) × 10^9/L; total red blood cell count, (10.56 ± 1.19) × 10^{12}/L and (10.59 ± 0.98) × 10^{12}/L; total platelet count, (473.10 ± 39.90) × 10^9/L and (433.20 ± 58.36) × 10^9/L; lymphocyte count, (215.34 ± 18.32) × 10^9/L and (217.72 ± 20.47) × 10^9/L; and hemoglobin content, (136.10 ± 10.68) and (150.10 ± 12.36) g/L. Blood physiological indicators including total white blood cell count, lymphocyte count, lymphocyte percentage, hemoglobin content, total red blood cell count, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, red blood cell distribution width-coefficient of variation, and total platelet count showed no significant differences between male and female Hu sheep ($P > 0.05$).

Table 1 Physiological parameters of Hu sheep in autumn

Sex	Sample No. (N)	Body temperature//℃	Respiratory rate breaths//min	Heart rate beats//min
Ram	10	39.71 ± 0.29	36.30 ± 2.45	80.50 ± 7.66
Ewe	10	39.19 ± 0.21	35.30 ± 3.31	90.50 ± 9.05
P value		0.00	0.73	0.02

Blood biochemical indicators

As shown in Table 3, for the Hu sheep raised in the Zizhong area, the following blood biochemical parameters were recorded for rams and ewes, respectively: blood glucose content, (8.30 ± 0.66) and (3.83 ± 0.21) mmol/L; alanine aminotransferase content, (24.70 ± 2.09) and (21.00 ± 1.95) U/L; alkaline phosphatase content, (213.20 ± 21.58) and (319.20 ± 28.34) U/L; creatine kinase content, (230.40 ± 22.18) and (213.10 ± 20.14) U/L; total protein content, (83.07 ± 4.83) and (82.12 ± 8.55) g/L; albumin content, (31.95 ± 1.97) and (32.32 ± 1.67) g/L; and globulin content, (96.03 ± 8.52) and (49.80 ± 4.46) g/L. Blood biochemical indicators of Hu sheep, including albumin, total protein, globulin, albumin/globulin ratio, calcium, glucose, urea nitrogen, inorganic phosphorus, amylase, cholesterol, alanine aminotransferase, total bilirubin, alkaline phosphatase, and creatine kinase, showed no significant differences between male and female sheep ($P > 0.05$). The blood creatinine level in rams was significantly higher than that in ewes ($P < 0.05$), while the urea nitrogen/creatinine ratio in ewes was significantly higher than that in rams ($P < 0.05$).

Table 2 Blood physiological parameters of Hu sheep in autumn

Sex	Sample No. (N)	Total white blood cell count//10^9/L	Lymphocyte count//10^9/L	Lymphocyte percentage//%	Hemoglobin concentration//g/L	Total red blood cell count//10^{12}/L	Hematocrit %
Ram	10	227.99 ± 23.20	215.34 ± 18.32	90.03 ± 6.65	136.10 ± 10.68	10.56 ± 1.19	50.37 ± 6.70
Ewe	10	242.54 ± 24.48	217.72 ± 20.47	94.59 ± 2.26	150.10 ± 12.36	10.59 ± 0.98	52.80 ± 5.28
P value		0.19	0.78	0.055	0.29	0.97	0.57

Sex	Sample No. (N)	Mean corpuscular volume (MCV)//fl	Mean corpuscular hemoglobin (MCH)//10^{12}g	Mean corpuscular hemoglobin concentration (MCHC)//g/L	Red cell distribution width-coefficient of variation (RDW-CV)//%	Total platelet count//10^9/L
Ram	10	48.60 ± 5.12	12.95 ± 0.78	268.68 ± 26.69	10.83 ± 0.79	473.10 ± 39.90
Ewe	10	51.42 ± 6.84	15.41 ± 1.59	262.57 ± 21.73	9.74 ± 0.53	433.20 ± 58.36
P value		0.31	0.56	0.88	0.082	0.74

Table 3 Blood biochemical parameters of Hu sheep in autumn

Sex	Sample No. (N)	Albumin g/L	Total protein g/L	Globulin g/L	Albumin-to-globulin ratio (A/G ratio)	Calcium (Ca) mmol/L	Glucose (Glu) mmol/L	Blood urea nitrogen (BUN) mmol/L	Inorganic phosphorus (IP) mmol/L
Ram	10	31.95 ±1.97	83.07 ±4.83	96.03 ±8.52	0.65 ±0.04	2.41 ±0.21	8.30 ±0.66	5.31 ±0.42	2.10 ±0.18
Ewe	10	32.32 ±1.67	82.12 ±8.55	49.80 ±4.46	0.67 ±0.05	2.50 ±0.23	3.83 ±0.21	6.54 ±0.55	1.85 ±0.15
P value		0.656	0.763	0.317	0.736	0.162	0.321	0.119	0.364

Sex	Sample No. (N)	Amylase (AMS)//U/L	Cholesterol (CHOL) mmol/L	Alanine aminotransferase (ALT)//U/L	Total bilirubin (TBIL) μmol/L	Alkaline phosphatase (ALP)//U/L	Creatinine (CREA) μmol/L	Urea nitrogen-to-creatinine ratio (BUN/CREA ratio)	Creatine kinase (CK) U/L
Ram	10	14.20 ±1.24	2.42 ±0.19	24.70 ±2.09	9.96 ±2.67	213.20 ±21.58	75.60 ±6.64	18.50 ±1.59	230.40 ±22.18
Ewe	10	11.20 ±0.98	2.54 ±0.22	21.00 ±1.95	7.98 ±2.48	319.20 ±28.34	49.70 ±4.87	34.90 ±2.37	213.10 ±20.14
P value		0.495	0.581	0.367	0.102	0.070	0.001	0.003	0.709

Conclusion and Discussion

Normal physiological indicators in animals reflect the relationship between the internal substance and external performance of the animal body. They can also characterize and reveal changes related to breed, sex, age, region, external environment, and physiological status, while maintaining relative stability. Once changes occur, they reflect alterations in the animal's metabolism and physiological or pathological conditions[6]. The body temperatures of male and female Hu sheep introduced to the Zizhong area of Sichuan Province after adaptation were (39.71 ± 0.29) and (39.19 ± 0.21) ℃, respectively. Their respiratory rates were (36.30 ±2.45) and (35.30 ±3.31) breaths/min, respectively, and their heart rates were (80.50 ±7.66) and (90.50 ±9.05) beats/min, respectively. Judging from the physiological indicators of Hu sheep in autumn, including body temperature, respiratory rate, and heart rate, all measured parameters were relatively stable and fell within the normal physiological range for healthy sheep. It suggests that Hu sheep have good adaptability to breeding in the Zizhong area.

Blood physiological indicators of livestock and poultry can reflect their health status, serving as an important reference basis for scientific feeding management, disease diagnosis, and other aspects[7-8]. They also serve as criteria for determining whether livestock and poultry raised in different regions have adapted to the new environment. Wang *et al.* [9] measured the blood physiological and biochemical indicators of Hu sheep introduced to the hot and humid regions of Southwest China, and referred to the normal reference values for adult sheep in China to determine whether Hu sheep had adapted to this area. Xie *et al.* [10] measured the blood physiological and biochemical indicators of Hu sheep introduced to the alpine regions of Northwest China to assess their adaptability to that region, thereby providing a scientific basis for the breeding and promotion of Hu sheep in that area. The 11 blood physiological indicators measured in this study for Hu sheep in autumn were all within the reference ranges for healthy sheep, and no significant differences were observed between rams and ewes.

Biochemical indicators in animal blood reflect the comprehensive factors of the animal's nutritional status, metabolic condition, internal and external environmental balance, growth and development, and production performance. They play an important role in aspects such as substance metabolism, energy transfer, information transcription, immune regulation, and growth and development[6]. The 16 blood biochemical indicators measured in this study for Hu sheep in autumn were all within the reference ranges for healthy sheep. Among these, 14 indicators, including albumin, total protein, and globulin, showed no significant differences between rams and ewes. Only the creatinine level in rams was significantly higher than that in ewes, while the urea nitrogen/creatinine ratio in ewes was significantly higher than that in rams. Combined with the measured physiological indicators and blood physiological and biochemical parameters, the results demonstrate that Hu sheep exhibit good adaptability in this area.

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map-based cloning should be deepened to systematically uncover key functional genes in the bolting regulatory network. Second, the dynamic regulatory mechanisms of epigenetic modifications in vernalization memory maintenance and bolting initiation should be systematically elucidated, with particular attention to the functional conservation and species specificity of PRC2-mediated histone modification pathways in radish. Third, a marker-assisted selection system based on genome-wide association studies should be established to improve the efficiency of selecting bolting-tolerant traits. Fourth, the ecological adaptability evaluation of bolting-tolerant varieties and the integration of supporting cultivation techniques should be strengthened to promote the transformation of research findings into production applications. With the continued development of genomics, epigenetics, and gene editing technologies, the molecular code of radish bolting is expected to be fully deciphered. The independent breeding of bolting-tolerant radish varieties is set to enter a fast track, providing strong scientific and technological support for the stable development and year-round balanced supply of China's radish industry.

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