Physiological and Biochemical Parameters of Hu Sheep in the Zizhong Area of Sichuan Province in Spring

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Abstract [**Objectives**] This study was conducted to investigate the characteristics of physiological, hematological and blood biochemical parameters in introduced Hu sheep reared in the Zizhong area of Sichuan Province in spring. [**Methods**] Ten healthy adult rams and ten healthy adult ewes aged 3 - 5 years were selected, and relevant parameters were measured. [**Results**] No significant differences were observed between rams and ewes in body temperature, respiratory rate, and heart rate ($P > 0.05$). Among hematological parameters, except for a significantly higher total platelet count in ewes ($P < 0.05$) and a significantly higher lymphocyte percentage in rams ($P < 0.05$), no significant differences were found between rams and ewes in other 11 indicators, including total red blood cell count, total white blood cell count, and hemoglobin concentration ($P > 0.05$). Among blood biochemical parameters, blood urea nitrogen (BUN), alanine aminotransferase (ALT), and the urea nitrogen-to-creatinine ratio were significantly higher in rams than in ewes ($P < 0.05$). No significant differences ($P > 0.05$) were observed between rams and ewes in 13 indicators, including total protein, albumin, glucose, and creatine kinase (CK). Overall, the physiological, hematological, and blood biochemical parameters of Hu sheep under housed conditions in the Zizhong area remained stable, with only a few indicators showing significant differences between sexes. This pattern reflects subtle physiological regulatory differences in metabolism and immune function between rams and ewes. [**Conclusions**] This study provides fundamental data for understanding the physiological adaptability of Hu sheep in the region.

Key words Hu sheep; Body temperature; Physiological parameter; Biochemical parameter; Heart rate

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The Hu sheep is a valuable genetic resource of livestock and poultry in China, as well as a world-renowned prolific sheep breed. Originating from Mongolian sheep, its distribution gradually expanded to the Taihu Lake basin following the southward migration of northern populations during the Southern Song Dynasty. Through over 800 years of artificial selection and adaptation in the border region of Jiangsu, Zhejiang, and Shanghai, it has developed distinctive breed characteristics. Hu sheep, with their excellent reproductive performance, are characterized by early sexual maturity (first estrus at 4 - 5 months of age), year-round estrus, multiple births and multiple lambs (lambing rates up to 200% - 270%), and good lactational performance. Under optimal management, they can achieve an efficient reproductive cycle of two births per year or three births every two years. Additional valuable traits include rapid early growth, tolerance to high temperature and humidity, and excellent adaptation to the environment of house feeding. These characteristics collectively establish Hu sheep as a highly promising breed for widespread adoption in the modernization and transformation of agriculture.

Sichuan Province, located in the inland southwest of China, features diverse climate types, with most regions characterized by a subtropical humid climate marked by relatively high temperatures, significant humidity, and abundant rainfall. These climatic conditions share certain similarities with the Taihu Lake basin, the native habitat of Hu sheep, suggesting potential suitability for the introduction of this breed. Furthermore, Sichuan Province has rich agricultural resources, including ample fodder supplies such as crop straws and forage grasses, which provide a solid material foundation for developing housed sheep production systems. Concurrently, Sichuan has a robust mutton consumption market with consistently growing demand, creating a need to introduce superior breeds to enhance local mutton productionand quality. However, differences persist between Sichuan and the native region of Hu sheep in terms of geographical environment, altitude, and feed composition. These ifferences may impact the physiological status of introduced Hu sheep, necessitating further monitoring of physiological, hematological and blood biochemical parameters in the introduced Hu sheep population.

In recent years, extensive research has been conducted on the adaptability of introduced breeds, encompassing physiological, hematological and blood biochemical studies. Basic vital signs such as body temperature, respiratory rate, and heart rate directly reflect an animal's physiological response to environmental conditions. Hematological indicators provide insight into immune status and blood metabolism characteristics, while blood biochemical parameters reveal the metabolic status of proteins, lipids, and carbohydrates, as well as the functional state of vital organs such as the liver and kidneys. Together, these parameters play a crucial role in monitoring the adaptability of introduced breeds. In this study, physiological, hematological and blood biochemicalparameters in Hu sheep introduced to and reared in the Zizhong area of Sichuan Province were measured and analyzed during spring, aiming to provide a basis for evaluating the adaptability of Hu sheep to the Zizhong area of Sichuan Province in spring.

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Materials and Methods

Experimental animals

This experiment was conducted using Hu sheep from a farm inZizhong County of Sichuan Province. Ten adult rams and ten adult ewes, aged 3 – 5 years, were randomly selected. The sheep had been reared under a housed system for at least one year.

Physiological indicator

Between 6:00 and 8:00 am in spring, under quiet environmental conditions, rectal temperature, heart rate, and respiratory rate were measured when the sheep were in a calm state.

Blood sample collection

Fasting sheep were subjected to jugular venipuncture in the morning to collect 6 – 8 ml of blood. From this sample, 3 – 4 ml was transferred into a disposable vacuum blood collection tube pretreated with EDTA-K2 anticoagulant. The tube was gently inverted several times to ensure thorough mixing of the anticoagulant with the fresh blood. The remaining blood was transferred into a separate vacuum blood collection tube without anticoagulant, and no mixing was performed, allowing the blood to coagulate naturally. The collected samples were stored at low temperature and promptly transported to the ShuangliuAixin Animal Hospital for analysis of various hematological and biochemical parameters.

Statistical analysis

Raw data were processsed using Excel. Statistical analysis was performed with IBM SPSS Statistics 22, and results are presented as mean ± standard deviation ($\bar{x} \pm s$).

Results and Analysis

Physiological indicators

As shown in Table 1, the body temperature of Hu sheep reared in the Zizhong area was (38.74 ± 0.44) ℃ for rams and (38.78 ± 0.16) ℃ for ewes in spring. The respiratory rate was (38.90 ± 2.77) breaths/min for rams and (40.20 ± 6.92) breaths/min for ewes. The heart rate was (82.90 ± 6.67) beats/min for rams and (88.10 ± 6.21) beats/min for ewes. No significant differences were observed between rams and ewes in body temperature, respiratory rate, or heart rate($P > 0.05$).

Table 1 Physiological parameters of Hu Sheep in spring

Sex	Sample No. (N)	Body temperature//℃	Respiratoryrate breaths/min	Heart rate beats/min
Ram	10	38.74 ± 0.44	38.90 ± 2.77	82.90 ± 6.67
Ewe	10	38.78 ± 0.16	40.20 ± 6.92	88.10 ± 6.21
P value		0.79	0.59	0.09

Hematological indicators

As shown in Table 2, the following parameters were recorded for rams and ewes, respectively: total red blood cell count, (12.96 ± 1.68) × 10^{12}/L and (13.38 ± 1.98) × 10^{12}/L; hemoglobin concentration, (107.00 ± 9.44) and (119.60 ± 9.23) g/L; total white blood cell count, (212.95 ± 23.12) × 10^{9}/L and (222.06 ± 24.90) × 10^{9}/L; lymphocyte count, (206.86 ± 24.97) × 10^{9}/L and (210.70 ± 22.03) × 10^{9}/L; and total platelet count, (263.40 ± 22.09) × 10^{9}/L and (387.80 ± 25.80) × 10^{9}/L. No significant differences were observed between rams and ewes in total red blood cell count, total white blood cell count, lymphocyte count, hemoglobin concentration, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, or red cell distribution width-coefficient of variation($P > 0.05$). However, the lymphocyte percentage was significantly higher in rams than in ewes ($P < 0.05$), while the total platelet count was significantly higher in ewes than in rams ($P < 0.05$).

Table 2 Hematological parameters of Hu sheep in spring

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	212.95 ± 23.12	206.86 ± 24.97	95.88 ± 2.44	107.00 ± 9.44	12.96 ± 1.68	60.45 ± 5.41
Ewe	10	222.06 ± 24.90	210.70 ± 22.03	94.96 ± 1.26	119.60 ± 9.23	13.38 ± 1.98	63.28 ± 9.04
P value		0.41	0.72	0.042	0.26	0.61	0.48

Sex	Sample No. (N)	Mean corpuscular volume (MCV)//fl	Mean corpuscular hemoglobin (MCH)//pg	Mean corpuscular hemoglobin concentration (MCHC)//g/L	Red cell distribution width-coefficient of variation (RDW-CV)//%	Total platelet count//10^{9}/L
Ram	10	46.66 ± 2.05	8.19 ± 0.67	175.74 ± 11.98	10.18 ± 0.46	263.40 ± 22.09
Ewe	10	47.48 ± 4.44	8.89 ± 1.16	187.40 ± 12.18	10.10 ± 0.56	387.80 ± 25.80
P value		0.60	0.12	0.15	0.730	0.03

Blood biochemical indicators

As shown in Table 3, the total protein level was (75.35 ± 3.90) g/L for rams and (78.20 ± 4.54 g/L) for ewes. The albumin level was (30.77 ± 1.81) g/L for rams and (29.69 ± 2.43) g/L for ewes. The globulin level was (44.58 ± 4.69) g/L for rams and (48.51 ± 4.43) g/L for ewes. The glucose concentration was (3.75 ± 0.45) mmol/L for rams and (3.47 ± 0.41) mmol/L for ewes. The alanine aminotransferase (ALT) activity was (28.10 ± 2.74) U/L for rams and (20.22 ± 2.63) U/L for ewes. The alkaline phosphatase (ALP) activity was (195.80 ± 17.17) U/L for rams and (152.11 ± 13.75 U/L) for ewes. The creatine kinase (CK) activity was (217.10 ± 22.47) U/L for rams and (334.00 ± 27.45) U/L for ewes. No significant differences ($P > 0.05$) were observed between rams and ewes in albumin, total protein, globulin, albumin-to-globulin ratio, calcium, glucose, inorganic phosphorus, amylase, cholesterol, total bilirubin, alkaline phosphatase (ALP), creatinine, or creatine kinase. However, blood urea nitrogen (BUN), alanine aminotransferase (ALT), and the urea nitrogen-to-creatinine ratio were significantly higher in rams than in ewes ($P < 0.05$).

Table 3 Blood biochemical parameters of Hu sheep in spring

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	30.77 ± 1.81	75.35 ± 3.90	44.58 ± 4.69	0.70 ± 0.05	2.26 ± 0.21	3.75 ± 0.45	7.02 ± 0.67	1.99 ± 0.16
Ewe	10	29.69 ± 2.43	78.20 ± 4.54	48.51 ± 4.43	0.64 ± 0.04	2.35 ± 0.22	3.47 ± 0.41	2.36 ± 0.24	1.66 ± 0.15
P value		0.284	0.159	0.143	0.305	0.359	0.281	0.000	0.197

Sex	Sample No. (N)	Amylase (AMS) // U/L	Cholesterol (CHOL) mmol/L	Alanine aminotransferase (ALT) // U/L	Total bilirubin (TBIL) umol/L	Alkaline phosphatase (ALP) // U/L	Creatinine (CREA) umol/L	Urea nitrogen-to-creatinine ratio (BUN/CREA ratio)	Creatine kinase (CK) U/L
Ram	10	12.10 ± 1.16	2.03 ± 0.19	28.10 ± 2.74	8.77 ± 0.78	195.80 ± 17.17	79.50 ± 6.83	24.10 ± 2.53	217.10 ± 22.47
Ewe	10	10.44 ± 1.04	2.16 ± 0.23	20.22 ± 2.63	10.52 ± 1.09	152.11 ± 13.75	62.78 ± 5.55	10.11 ± 0.98	334.00 ± 27.45
P value		0.736	0.457	0.012	0.297	0.096	0.233	0.000	0.198

Conclusions and Discussion

Vital signs such as body temperature, heart rate, and respiratory rate form the foundation for maintaining normal physiological activity in animals and serve as crucial indicators for diagnosing diseases and assessing overall health status. Hu sheep introduced to and reared in the Zizhong area of Sichuan exhibited following physiological parameters in spring: body temperature, (38.74 ± 0.44) ℃ for rams and (38.78 ± 0.16) ℃ for ewes; respiratory rate, (38.90 ± 2.77) breaths/min for rams and (40.20 ± 6.92) breaths/min for ewes; and heart rate, (82.90 ± 6.67) beats/min for rams and (88.10 ± 6.21) beats/min for ewes. All measured parameters fell within the normal physiological range for sheep. These vital sign values are largely consistent with those reported for Hu sheep introduced to and reared in the cold northwestern regions[1] and Henan Province[2] of China. However, certain differences were noted when compared with findings from Jili Amei *et al.*[3]. Based on the assessment of these vital signs, Hu sheep introduced to and reared in the Zizhong area demonstrate favorable adaptability.

The blood of livestock and poultry is directly involved in their metabolic processes, transporting raw materials required for cellular metabolism and removing metabolic waste products. Normal physiological blood parameters not only reflect the direct relationship between the animal's internal constitution and external performance, but also indicate characteristics and variations related to breed, sex, age, geographic region, differing external environments, and distinct physiological states[4]. These parameters exhibit relative stability, and any deviation can serve as an indicator of alterations in animal's metabolism and physiological or pathological conditions[5]. In this study, the hematological and biochemical parameters of Hu sheep introduced to the Zizhong area of Sichuan remained relatively stable between rams and ewes. Among the hematological indicators, no significant differences were observed between sexes in nine parameters, including total red blood cell count, total white blood cell count, lymphocyte count, and hemoglobin concentration. Differences were noted only in two parameters: lymphocyte percentage and total platelet count. Among the blood biochemical indicators, no significant differences were observed between sexes in thirteen parameters, including albumin, total protein, globulin, alkaline phosphatase, and creatine kinase. Differences were present only in three parameters: blood urea nitrogen, alanine aminotransferase, and the urea nitrogen-to-creatinine ratio. Hu sheep introduced to and reared in the Zizhong area exhibited hematological and blood biochemical parameters consistent with previous findings[1,3,6]. Overall, their physiological functions remained within normal ranges.

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