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# EVALUATION OF HEMATOLOGICAL PARAMETERS, SERUM BIOCHEMICAL PROFILE AND MORPHOMETRIC TRAITS OF SHEEP BREEDS OF QUETTA

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**Abstract**

*The sheep are an integral component of the local pastoral economy in Pakistan, especially in dry, barren and mountainous regions. The present study was conducted to evaluate the hemato-biochemical indices and phenotypic traits of four indigenous sheep breeds of Balochistan: Balochi, Mangali, Harnai and Shinwari. The blood samples were collected from clinically healthy adult sheep (n=80 per breed) and hematological parameters (Hb, PVC, ESR, RBCs, WBCs and DLC counts, MCV, MCH, MCHC), hepatic (ALT, AST) and renal (urea, creatinine) function biomarkers, serum biochemical analyses (glucose, total protein, albumin, globulin) and lipid profile (cholesterol, triglycerides, LDL, VLDL, HDL) were analyzed along with recording the morphological traits (body parts dimensions, height, length and width of different areas) to determine the phenotypic variability among the breeds. The data of the current study suggest that Mengali and Shinwari breeds are found to possess superior oxygen-carrying capacity, with a potentially active immune profile. The Shinwari is an energy-optimized, heavy muscle producer, whose energy is concentrated into muscle formation rather than bone or skeleton development. The Balochi breed displayed an evolutionary adaptation for long-distance trekking and browsing in sparse arid rangelands. The Mengali breed has a highly developed digestive capacity with an intense metabolic genotype, accelerated hepatic enzyme activity, efficient fat metabolism and enhanced triglyceride storage to maximize the nutritional utilization during periods of nutritional scarcity. Thus, these results demonstrate significant inter-breed variations in both physiological and phenotypic parameters and provide essential data for physiological characterization and selective breeding of specific breeds.*

**Keywords:** *Hematology, Lipid profile, Morphometric traits, Serum biochemistry, Sheep*

## INTRODUCTION

The small ruminants are mainly reared for farming purpose and are a key factor for enhancing the rural economics in Pakistan and especially in the dry, barren and mountainous regions of Baluchistan. According to 7th Agricultural Census report of Pakistan Bureau of Statistics (2024-25), the sheep population in Pakistan is 44.58 millions contributing significantly in the national GDP by their milk, meat, wool and hides production. The Baluchistan province has approximately 18.814 million sheep heads, more than other provinces of the country. The sheep (Ovis aries), contemporaneously with goats, were the first livestock species domesticated as food items in Fertile Crescent in the era of Holocene about 12,000 to 10,000 years ago (1). They are mainly raised for milk, meat and wool, which are necessary for nutrition and clothing of humans. The ewes can give birth to multiple lambs, even triplets at sometimes; efficiently increase the animal group size and thus the overall economic status of the farmer (2).

The sheep breeds in Balochistan arise from Western and Central Asia through tribal movement and have been modified and adapted locally. Among the sheep breeds of the region (Shinwari, Karagh, Balochi, Rakhshani, Dumari, Bivirikh, Mengali, Kakari), the most common breeds are Shinwari, Balochi, Mengali and Harnai that expand on the huge range lands of the province (3). Balochistan's fat-tailed sheep breeds like

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Balochi sheep are primarily raised through migratory nomads and transhumance families as compared to local residing population. The supply of meat is 14% of the total requirements of the country (4) and thus sheep farming assist the rural economies, especially in the dry regions of Balochistan. These key breeds of Balochistan show distinct traits like coarse wool, strong frames and climate resilience. Their phenotype and physiological diversity supports survival and productivity in the arid regions.

The breed-specific hematological, serum biochemical and phenotype traits variations persist among sheep breeds that differentiate one breed from another. These variations are mostly due to their adaptation to the specific environmental conditions like temperature, humidity, precipitation and availability of feed and water (5, 6). These physio-biochemical, hematological and phenotype parameters of sheep breeds of Balochistan reflect their adaptation to the harsh climate and thus aid in the breed characterization. These traits help in evaluating the metabolic status and functioning of different organs that are important for assessing the health conditions and production performance of animals. Hematological indices like PCV, RBCs and Hb differ in different breeds and thus indicate the physiological status and adaptability, as like the Merino sheep show higher levels of blood parameters and thus an increased oxygen transport capacity (7). Similarly, serum biochemical markers like protein, glucose, urea, creatinine, ALT and AST help to assess the physiological state of different organs, since these indices are widely used in veterinary disease diagnosis, to detect the metabolic conditions or presence of infectious (8).

To the best of our knowledge, previously these hematological parameters, serum biochemical indices and phenotype traits have not been reported among our selected sheep breeds of the province. Hence, it is quite important to investigate these parameters among these animals, to provide valuable insight into characterization of these breeds, well adapted in the harsh environment of the province. The findings of this study will be utilized for breeding perspective and selection programs, to provide an adequate protein source to the inhabitants of the province and to other regions of the country.

# METHODOLOGY

## STUDY AREA AND SELECTION OF SHEEP BREEDS

This cross-sectional study was conducted in Quetta district of Balochistan province. Four major sheep breeds namely Balochi, Mengali, Harnai and Shinwari were included in this study. The sheep breeds were identified on the basis of their phenotype characteristics and duly verified by genetic experts at Center for Advanced Studies in Vaccinology & Biotechnology, University of Balochistan, Quetta. Both rams (n=20) and ewes (n=20) of each breed, approximately at the age of 6 months, were included in the study. Hence, a total of 160 sheep were sampled. The phenotypic traits of each sheep were recorded by using pre-designed questionnaire.

## COLLECTION OF BLOOD SAMPLES AND HEMATOLOGICAL ANALYSIS

The blood sample (5 ml) was collected from the jugular vein of each sheep for hematological and biochemical analysis. For hematological study, blood was collected (2 ml) in blood collection vacutainers containing ethylene Di-amine tetra acetic acid (EDTA), as described earlier (9). The blood samples were transferred immediately to the Department of Physiology, Center for Advanced Studies in Vaccinology and Biotechnology (CASVAB), University of Balochistan, Quetta and stored at 4°C until further processing. The blood samples were analyzed by using a hematology analyzer, by commercially available kits to determine complete blood count (CBC), hematocrit (Hct), hemoglobin (Hb) concentration, erythrocytes (RBCs), leukocytes (WBCs) and platelets (PLTs) count.

## ANALYSIS OF SERUM BIOCHEMICAL PARAMETERS

For biochemical analysis, half of the blood sample (3 ml) was collected in EDTA free vacutainer / serum separator tubes. The blood sample was centrifuged at 4000 rpm for 15 minutes. The extracted serum was transferred in separate eppendorf tubes with proper labeling and stored at 20°C, until further analysis. To biochemical tests of urea, creatinine, ALT and AST, protein tests, lipid profile and glucose tests were performed by following the protocols of commercially available kits of urea (Innoline, Lot No: A240332),

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creatinine (Innoline, Lot No: D4491), ALT (Innoline, Lot No: A250085), AST (Innoline, Lot No: A250072), Glucose (Innoline, Lot No: A250045), total protein (Human, Lot No: 0129) by using Micro Lab 300 chemistry analyzer.

## MEASUREMENTS OF MORPHOMETRIC TRAITS

For the phenotype traits, weight (kg), height at withers (cm), rib depth (cm), body diagonal length (cm), body length (cm), pelvic girdle length (cm), rump depth (cm), rump height (cm), pin bone width (cm), abdomen width (cm), chest circumference (cm) and abdominal circumference (cm), head length (cm) and width (cm) of each sheep were measured by using standardized digital equipment, as described previously (10, 11).

## STATISTICAL ANALYSIS

The data obtained were entered into the Microsoft office excel sheet in tabulated form through excel-22 and further analyses was made with the help of Statistical Package for Social Sciences (SPSS) software.

## ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Ethical committee of Animal Experimentation at Center for Advanced Studies in Vaccinology and Biotechnology (CASVAB), University of Balochistan, Quetta.

# RESULTS

## DETERMINATION OF BLOOD PROFILE

Mengali males exhibit highest RBCs count (11.97±1.21×106/µl) and highest HCT (40.72±0.87 g/dL) and Hb (12.94±1.28 g/dL) values, while shinwari females have highest absolute erythrocytic number (11.59±0.29×106/µl) and highest HCT (31.47±1.81g/dL), PCV (38.83±2.40%) and Hb (10.49±0.97g/dL) values (Table I). Similarly, the shinwari males have highest mean corpuscular volume (MCV; 38.29±1.06fl) and hemoglobin values (MCH; 12.76±0.35pg, MCHC; 33.95±1.91g/dL), while Mengali females have highest erythrocytes size (MCV; 30.09±0.48fl) and Hb contents (MCH; 10.23±0.95pg, MCHC; 34.46±2.47g/dL). Shinwari males (425.91±13.21×103/µl) and Harnai females (436.65±15.57×103/µl) have high platelets counts (Table I).

## DETERMINATION OF IMMUNE CELLS PROFILE

Mengali males have highest leukocyte count (11.95±1.21×103/µl) and lymphocytes (62.72±4.04%) and basophils (0.59±0.06%) number, while Mengali females have highest neutrophils (41.47±1.58%) monocytes (7.61±0.56%) and basophils (0.57±0.05%). The Shinwari males have highest neutrophils (41.86±3.14%), monocytes (8.67±0.34%) and eosinophils (2.96±0.23%). Hence, both these breeds have higher immune cells profile than other our selected sheep species (Table I).

**Table I**. Hematological parameters of different sheep breeds

| Breeds | Balochi | Mengali | Harnai | Shinwari |
|---|---|---|---|---|
| RBC M (×$10^3$/µl) | 9.74±0.80 | 11.97±1.21 | 10.09±0.54 | 9.10±0.42 |
| RBC F (×$10^3$/µl) | 10.67±0.26 | 9.53±0.29 | 10.15±0.39 | 11.59±0.29 |
| WBC M (×$10^3$/µl) | 9.38±0.40 | 11.95±1.21 | 9.21±0.94 | 8.60±0.57 |
| WBC F (×$10^3$/µl) | 10.83±1.54 | 9.12±0.71 | 9.62±0.51 | 7.05±0.48 |
| HCT M (g/dL) | 32.03±1.85 | 40.72±0.87 | 30.66±1.19 | 34.28±2.84 |
| HCT F (g/dL) | 29.28±0.74 | 31.09±0.59 | 28.05±1.04 | 31.47±1.81 |
| PCV M (%) | 29.39±0.87 | 36.15±2.96 | 39.56±3.10 | 39.52±2.21 |
| PCV F (%) | 30.21±3.93 | 34.06±1.48 | 30.94±1.17 | 38.83±2.40 |
| ESR M (U/2 h) | 12.85±0.84 | 5.75±0.65 | 13.40±0.76 | 5.09±0.91 |
| ESR F (U/2 h) | 14.90±4.41 | 6.05±0.76 | 11.55±0.53 | 4.70±0.47 |
| Hb M (g/dL) | 9.93±0.90 | 12.94±1.28 | 10.83±1.31 | 11.50±1.27 |
| Hb F (g/dL) | 9.76±1.25 | 9.70±0.19 | 9.35±0.85 | 10.49±0.97 |

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| MCV M (fl) | 30.86±1.90 | 25.59±1.39 | 31.53±1.09 | 38.29±1.06 |
| MCV F (fl) | 26.58±1.30 | 30.09±0.48 | 27.67±2.30 | 32.20±0.34 |
| MCH M (pg) | 9.89±0.74 | 10.90±1.35 | 10.92±1.02 | 12.76±0.35 |
| MCH F (pg) | 9.15±0.90 | 10.23±0.95 | 9.22±0.80 | 10.71±0.09 |
| MCHC M (g/dL) | 32.75±1.14 | 32.79±2.13 | 33.46±1.74 | 33.95±1.91 |
| MCHC F (g/dL) | 32.82±1.93 | 34.46±2.47 | 33.27±0.19 | 34.11±2.14 |
| Platelets count M ($\times 10^3/\mu l$) | 295.15±14.82 | 329.07±19.27 | 367.26±9.48 | 425.91±13.21 |
| Platelets count F ($\times 10^3/\mu l$) | 307.92±18.03 | 372.36±16.37 | 436.65±15.57 | 390.43±18.84 |
| Neutrophils M (%) | 31.08±1.44 | 34.21±2.06 | 36.62±1.92 | 41.86±3.14 |
| Neutrophils F (%) | 27.42±1.21 | 41.47±1.58 | 39.25±2.37 | 35.33±1.74 |
| Lymphocytes M (%) | 50.54±2.03 | 62.72±4.04 | 57.70±3.02 | 53.80±1.76 |
| Lymphocytes F (%) | 50.34±1.89 | 55.65±1.79 | 58.28±2.39 | 67.58±4.25 |
| Monocytes M (%) | 3.24±0.41 | 7.18±0.54 | 4.21±0.46 | 8.67±0.34 |
| Monocytes F (%) | 3.66±0.34 | 7.61±0.56 | 5.33±0.27 | 4.22±0.41 |
| Eosinophils M (%) | 1.19±0.10 | 2.32±0.13 | 2.00±0.22 | 2.96±0.23 |
| Eosinophils F (%) | 1.63±0.21 | 1.69±0.23 | 1.91±0.20 | 1.32±0.14 |
| Basophils M (%) | 0.28±0.03 | 0.59±0.06 | 0.48±0.05 | 0.44±0.06 |
| Basophils F (%) | 0.24±0.04 | 0.57±0.05 | 0.41±0.03 | 0.54±0.04 |

ESR = erythrocytes sedimentation rate, WBC = white blood cells, RBC = red blood cells, Hb = hemoglobin, HCT = hematocrit, PCV = packed cell volume, MCV = mean corpuscular volume, MCH = mean corpuscular hemoglobin, MCHC = mean corpuscular hemoglobin concentration, M = male, F = female

## LIVER AND KIDNEYS FUNCTIONS INDICATORS AND LIPID PROFILE

The Mengali and Harnai breeds displayed elevated hepatic (ALT, AST) and renal (urea, creatinine) enzymes, while the lowest values of these parameters were observed in Balochi animals of both sexes. Similarly, total proteins and glucose were found higher in Shinwari males and females animals. While the females of all the breeds' demonstrated higher cholesterol and triglycerides levels than their corresponding males. The values of different parameters of lipid profile (LDL, VLDL, HDL) were found to be in the close range among different sheep breeds (Table II).

**Table II**. Serum biochemical indices of different sheep breeds

| Breeds | Balochi | Mengali | Harnai | Shinwari |
|---|---|---|---|---|
| ALT M (U/L) | 20.50±0.56 | 32.07±0.79 | 25.32±0.29 | 24.96±0.33 |
| ALT F (U/L) | 21.02±1.31 | 28.29±0.30 | 29.29±1.18 | 25.37±0.33 |
| AST M (U/L) | 80.83±2.12 | 92.01±1.48 | 100.69±0.92 | 95.71±1.34 |
| AST F (U/L) | 74.55±2.36 | 93.12±2.60 | 92.03±0.96 | 87.09±1.03 |
| Urea M (mg/dL) | 38.47±1.68 | 51.43±1.39 | 40.41±2.01 | 46.01±1.19 |
| Urea F (mg/dL) | 39.25±1.42 | 44.28±1.46 | 45.21±1.22 | 36.89±1.96 |
| Creatinine M (mg/dL) | 1.96±0.18 | 2.05±0.15 | 2.41±0.17 | 2.19±0.32 |
| Creatinne F (mg/dL) | 1.58±0.05 | 2.12±0.16 | 1.81±0.05 | 1.98±0.19 |
| TP M (mg/dL) | 74.76±2.16 | 79.31±1.65 | 67.08±1.90 | 80.42±2.44 |
| TP F(mg/dL) | 63.46±1.06 | 70.09±2.12 | 77.47±3.80 | 75.26±1.14 |
| ALB M (mg/dL) | 29.45±1.60 | 28.25±1.27 | 27.53±0.44 | 26.93±0.99 |
| ALB F (mg/dL) | 29.05±2.11 | 31.67±1.59 | 30.37±2.26 | 29.65±1.31 |
| Glo M (mg/dL) | 45.31±2.30 | 51.07±4.81 | 39.55±1.88 | 53.49±0.47 |
| Glo F (mg/dL) | 37.41±1.01 | 42.61±2.53 | 47.11±2.90 | 40.62±2.39 |
| Glucose M mg/d) | 51.81±3.03 | 53.71±1.29 | 51.36±0.77 | 57.28±1.23 |
| Glucose F mg/d) | 55.22±1.41 | 66.16±1.87 | 55.68±2.60 | 71.84±1.89 |
| Chol M (mg/d) | 54.12±2.22 | 67.28±2.53 | 73.58±2.56 | 61.80±3.15 |
| Chol F (mg/d) | 72.50±4.33 | 78.10±1.87 | 81.80±3.14 | 64.92±1.89 |
| TG M (mg/d) | 33.18±1.17 | 35.38±2.62 | 28.20±0.81 | 29.85±1.06 |

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| TG F (mg/d) | 31.18±1.24 | 36.09±1.93 | 29.18±2.32 | 31.43±0.89 |
| LDL M | 37.31±2.38 | 39.71±2.78 | 38.60±2.62 | 38.91±2.46 |
| LDL F | 30.55±1.54 | 34.16±1.95 | 42.93±3.10 | 36.26±1.94 |
| VLDL M | 6.64±0.23 | 6.08±0.52 | 5.64±0.66 | 5.97±0.21 |
| VLDL F | 6.24±0.25 | 7.22±0.91 | 7.34±0.82 | 5.89±0.18 |
| HDL M | 30.17±1.01 | 36.49±0.49 | 39.34±2.42 | 36.92±1.45 |
| HDL F | 35.72±0.95 | 36.72±1.08 | 29.23±1.23 | 38.78±0.82 |

AST = Aspartate Aminotransferase, ALT = Alanine Aminotransferase, TP = total proteins, ALB = albumin, Glo = globulins, Chol = cholesterol, TG = triglycerides, LDL= low density lipoproteins, VLDL = very low density lipoproteins, HDL = high density lipoproteins, M = male, F = female

## MORPHOMETRIC CHARACTERISTICS

The **Shinwari** is considered the superior of all four selected breeds by a significant margin, wherein the male (68.14±1.23kg) and female (49.46±3.16kg) animals were found to be heaviest among the selected breeds (Table III, IV). This breed consistently demonstrated the most pronounced skeletal and structural dimensions, exhibiting higher chest width (male; 32.66±1.19cm, females; 30.68±2.21cm), pin bone width (male; 14.76±0.96cm, females; 13.90±0.37cm), rump height (male; 59.35±3.01cm, females; 56.76±2.57cm) and depth (male; 43.00±1.32cm, females; 40.28±2.51cm), abdomen width (male; 39.90±1.64cm, females; 37.99±3.29cm) and body diagonal length (male; 127.09±3.50cm, females; 125.21±4.53cm). Conversely, these heavy Shinwari males and females are much shorter in height (males; 67.33±0.60cm, females; 56.09±0.37cm) and body length (males; 71.73±3.29cm, females; 69.74±2.29cm) than other three breeds. The Balochi breed is higher in withers height (males; 72.93±4.24cm, females; 68.09±2.33cm) and body length (males; 80.26±3.86cm, females; 78.29±2.87cm). The Mengali breed features deepest ribs (males; 34.26±0.43cm, females; 33.67±0.68cm) and largest chest circumferences (males; 106.27±5.16cm, females; 104.34±3.17cm). Compared to these breeds, the Harnai breed demonstrated its different parameters in the comparable range with other breeds, without any distinctive characteristics. Across all these four breeds, a distinct trend of sexual dimorphism has also been observed, with males consistently exhibiting higher mean values of nearly all these anatomical parameters compared to their female counterparts, thereby underscoring the influence of sex on the phenotypical expression of these local breeds (Table III, IV).

**Table III**. Phenotypical measurements of different sheep breeds

| Breeds | Balochi | Mengali | Harnai | Shinwari |
|---|---|---|---|---|
| Weight M (kg) | 41.31±2.83 | 62.26±4.04 | 50.77±3.07 | 68.14±1.23 |
| Weight F (kg) | 32.77±1.27 | 47.00±2.32 | 36.19±1.42 | 49.46±3.16 |
| Height withers M (cm) | 72.93±4.24 | 65.90±0.70 | 70.91±0.62 | 67.33±0.60 |
| Height withers F (cm) | 68.09±2.33 | 70.64±0.63 | 66.29±1.46 | 56.09±0.37 |
| Rib depth M (cm) | 25.96±1.03 | 34.26±0.43 | 32.32±1.37 | 37.22±1.61 |
| Rib depth F (cm) | 23.78±0.96 | 33.67±0.68 | 29.70±0.58 | 30.46±0.79 |
| Chest width M (cm) | 22.24±1.55 | 31.89±0.90 | 24.70±1.32 | 32.66±1.19 |
| Chest width F (cm) | 21.19±1.17 | 28.35±0.69 | 22.61±2.52 | 30.68±2.21 |
| Chest circum M (cm) | 96.67±4.29 | 106.27±5.16 | 86.43±2.15 | 72.56±0.21 |
| Chest circum F (cm) | 92.72±4.84 | 104.34±3.17 | 84.51±2.08 | 65.02±0.17 |
| Pin bone width M (cm) | 13.48±1.36 | 14.20±0.44 | 13.12±0.26 | 14.76±0.96 |
| Pin bone width F (cm) | 11.83±0.71 | 13.79±0.63 | 9.93±1.31 | 13.90±0.37 |
| Body diagonal length M (cm) | 117.00±4.65 | 120.14±2.99 | 118.67±2.87 | 127.09±3.50 |
| Body diagonal length F (cm) | 112.81±2.75 | 120.00±3.79 | 116.67±3.87 | 125.21±4.53 |
| Body length M (cm) | 80.26±3.86 | 77.37±1.24 | 75.12±4.35 | 71.73±3.29 |
| Body length F (cm) | 78.29±2.87 | 75.30±3.29 | 73.08±1.36 | 69.74±2.29 |

Circum = circumference; M = Male, F = Female

**Table IV**. Phenotypical measurements of different sheep breeds

| Breeds | Balochi | Mengali | Harnai | Shinwari |
|---|---|---|---|---|
| Rump height M (cm) | 38.46±1.89 | 30.46±2.27 | 26.01±0.45 | 59.35±3.01 |

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| Rump height F (cm) | 37.46±1.92 | 29.34±1.68 | 25.01±0.45 | 56.76±2.57 |
| Rump depth M (cm) | 23.24±0.44 | 35.03±0.62 | 21.88±0.23 | 43.00±1.32 |
| Rump depth F (cm) | 22.35±1.49 | 33.89±2.51 | 20.83±1.74 | 40.28±2.51 |
| Abdomen width M(cm) | 30.72±0.88 | 30.49±2.87 | 32.59±3.39 | 39.90±1.64 |
| Abdomen width F (cm) | 27.39±0.80 | 31.13±1.86 | 31.64±2.26 | 37.99±3.29 |
| Abdomen Cir M (cm) | 105.78±4.31 | 116.63±3.13 | 96.62±2.25 | 82.93±4.34 |
| Abdomin Cir F (cm) | 89.86±3.38 | 96.18±4.70 | 103.50±1.55 | 75.14±5.22 |
| Head length M (cm) | 24.36±0.16 | 24.96±2.41 | 23.46±0.41 | 25.56±2.52 |
| Head length F (cm) | 22.84±2.13 | 25.57±1.27 | 23.53±0.40 | 24.27±1.50 |
| Head width M (cm) | 14.26±0.27 | 12.05±0.02 | 12.13±2.02 | 22.20±1.72 |
| Head width F (cm) | 13.30±1.25 | 11.21±0.14 | 11.89±1.06 | 20.14±1.34 |
| Ear length M (cm) | 25.44±1.81 | 20.61±0.85 | 13.73±1.93 | 20.20±1.32 |
| Ear length F (cm) | 24.97±1.74 | 19.30±0.90 | 12.74±0.93 | 18.13±1.30 |
| Wrist height M (cm) | 72.76±4.33 | 77.50±3.26 | 65.02±2.70 | 80.70±4.34 |
| Wrist height F (cm) | 71.76±3.54 | 76.50±2.97 | 64.23±3.68 | 79.63±3.32 |
| Pelvic girdle length M (cm) | 73.97±3.37 | 71.75±3.06 | 65.06±4.44 | 80.80±2.72 |
| Pelvic girdle length F (cm) | 71.97±5.62 | 69.80±2.46 | 63.02±2.43 | 78.77±3.31 |

Cir = circumference; M = Male, F = Female

# DISCUSSION

The data showed that Mengali and Shinwari breeds are metabolically robust in oxygen transport via blood circulation; having blood profile (RBCs count, PCV, HCT, Hb) better than other breeds, their blood is quite rich in oxygen carrying cells and even their oxygen carrying capacity is also better than other breeds. It has also been found that Shinwari males have exceptionally high MCV and MCH values that indicate macrocytosis or larger RBCs which are capable of holding more hemoglobin (12). This is usually an evolutionary trait developed in selected breeds of animals that are habitants and adapted to harsh mountainous terrain at higher altitudes where oxygen efficiency and utilization is fairly important and thus could be correlated with increased metabolic activity (13, 14). Since, both these breeds are traditionally reared by pastoralists and nomads grazing the animals at high mountainous altitudes of different districts of Quetta, Kalat and Mastung, where the lower oxygen density at high altitudes triggers the kidneys to secrete erythropoietin that stimulates the bone marrow to accelerate the process of erythropoiesis (15, 16). The increased production of more and larger RBCs maximizes the blood oxygen-carrying capacity, allowing these breeds to thrive better in the mountain air. The forage quality at rangelands greatly fluctuates across different seasons of the year with shorts episodes of fodder scarcity and thus the breeds of the region like Mengali and Shinwari are genetically adapted for variable metabolic pathways, to optimize the iron utilization and amino acid absorption from the low-quality coarse pastures of mountains (17). The efficient iron absorption supports the heme synthesis, resulting in well-functioning RBCs with highly saturated hemoglobin, even under the conditions of nutritional stress (18).

Beyond the environmental triggers, the hematological values are fixed genetic traits that are established through several generations of natural and selective breeding. These genetic variations influence the response of bone marrow to oxygen deficiency at high altitudes, lifespan of circulating erythrocytes and the efficiency of splenic cellular reservoir (19). Thus, Mengali and Shinwari breeds are naturally evolved to have a high-yield circulatory blood picture to sustain during heavy physical and environmental exertions, required across rugged and mountainous landscapes. Moreover, the high platelets counts in Shinwari and Harnai breeds demonstrate a more efficient clotting mechanism that is advantageous for recovery during common injuries in rough grazing terrains. The WBCs are the primary indicators of strength of immune system and its reaction to pathogenic invaders. A higher immune cells profile with increased differential leukocytic count in Mengali and Shinwari breeds indicate a primed immune system capable of a stronger response to acute (neutrophils) and chronic (monocytes) infection or it might be that the animals are under active stress due to harsh environmental and husbandry conditions

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(20). In small ruminants especially sheep, lymphocytes usually make-up the highest percentage of WBCs indicating a robust capacity of developing a targeted long-term adaptive immune mechanism against bacterial infections that is crucial for disease resistance in pasture environments (21).

The evaluation of function of liver and kidneys demonstrate the metabolic health (proteins, lipids, glucose) of the animals across different animal breeds. The increased hepatic function biomarkers in Mengali and Harnai breeds indicate a more active liver metabolism, associated with an efficient processing of fodder rich in secondary plant compounds. Higher serum levels of urea and creatinine levels reflect elevated renal filtration efficiency and increased dietary or muscle protein breakdown due to higher physical and walking activity in the mountains areas (22). The Shinwari sheep displayed highest total proteins in both males and females and increased globulins in males that are the building blocks of antibodies and thus aligns with highly active immune mechanism with increased immune cells among their white blood cells. In the same context, a higher glucose contents in Shinwari breed is suggestive of a highly efficient liver to produce glucose (gluconeogenesis), suggesting a robust energy production mechanism to withstand the environmental stress during cold weather (23). An interesting fact has been observed that the ewes has consistently shown higher glycemia levels than the rams, reflecting a different energy demands likely to be linked with pregnancy and lactation (24). Similarly, the females of all four breeds have found to contain high cholesterol and triglycerides serum levels suggests an active lipid mobilization through circulating cholesterol and triglycerides as a metabolic energy buffer that closely aligns with metabolic adaptations in the pregnant animals, since an increased plasma cholesterol level is considered a marker of good metabolic condition in the lactating dairy cattle (25). During pregnancy and especially in the late gestation period, the metabolic demand of growing fetus and imminent requirements for lactation triggers the metabolic changes in the ewe. The period of late pregnancy is a time of negative energy balance for many dams because the requirements of expanding uterus and fetal energy demands are at their highest levels and increases than the feeding capacity of the animal (26). Hence, to compensate the energy requirements, the ewe mobilizes the stored lipids from adipose tissue that ultimately elevates the circulating levels of triglycerides and free fatty acids.

From a livestock breeding perspective, these morphological traits demonstrate distinct adaptations of different sheep breeds to specific environments like mountains or flat grazing terrains and thus segregates the dual-purpose (meat+wool) or specific meat-type conformations (6). Thus, significant phenotypical variations have been observed among four studied sheep breeds, with distinctive patterns of sexual dimorphism in most morphometric traits. The body weight usually acts as the primary indicator of growth rate, skeletal size and genetic potential of meat producing or dual purpose breeds (27). The massive weight edge of Shinwari breed, paired with its distinct biochemical profile (high glucose and energy metrics), has been characterizes as heavy meat-type breed with rapid growth and strong feed-conversion capabilities. The width of pin bone usually estimates the pelvic area that is highly critical for evaluating the maternal traits and lambing ease. A wider pelvic floor drastically reduces the risk of difficult births and dystocia, especially when animals are giving birth to heavy, fast-growing lambs (28). This indicates that Shinwari females possess better maternal traits alongside their meat-type structural properties.

## CONCLUSIONS

These results illustrate distinct breed-specific physiological adaptations and sexual dimorphism between both sexes. The data of the current study suggest that Mengali and Shinwari breeds are found to possess superior oxygen-carrying capacities, with a potentially more active immune profile. The Shinwari is found to be the shortest and heaviest breed showing a compact, blocky conformation with widest chests typical of specialized meat production, whose energy is concentrated into muscle deposition rather than bone or skeleton growth. The combination of a wide chest and long diagonal body frame illustrates a cylindrical carcass shape that maximizes the surface area for dressing the extensive muscle mass. This structural phenotype is metabolically supported by a genotype that optimizes the energy utilization, found by elevated blood glucose and robust total protein levels. The Balochi breed has displayed as tallest and

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flat-ribbed breed with leggy conformation (high height-to-weight ratio). This skeletal conformation is an evolutionary adaptation for long-distance trekking and browsing in the sparse arid rangelands. The Mengali breed's massive thoracic circumference and abdominal capacity (great rib barrel structure) suggest a structural adaptation for a highly developed digestive capacity due to larger stomach volume. This phenotypical architecture works in connection with an intense metabolic genotype, marked by accelerated hepatic enzyme activity, efficient fatty acid processing and enhanced triglycerides storage, in order to maximize the nutritional utilization from poor-quality fibrous forage during the periods of nutritional scarcity.

## Conflict of interest

There is no conflict of interest in this study.

## Authors' contribution

YR & ISS Conceptualization; YR, KK & HAA Methodology; KK, HAA, DK & RT Data curation; ISS, HMA, AA & AIM Formal analysis; ISS, KK, HAA, MI, AIM & SU Investigation; YR, HMA, KK, AA, MI & ZBS Writing original draft preparation; YR, HAA, DK, SU & ZBS Writing review and editing; ISS & KK Supervision; ISS & SU Project administration.

## References


1. Sassi-Zaidy YB, Mohamed-Brahmi A, Chaouch M, Maretto F, Cendron F, Charfi-Cheikhrouha F, Ben Abderrazak S, Djemali M, Cassandro M. Historical Westward Migration Phases of Ovis aries Inferred from the Population Structure and the Phylogeography of Occidental Mediterranean Native Sheep Breeds. Genes. 2022;13(8):1421.
2. Erichsen C, Coombs T, Sargison N, McCoard S, Keady TWJ, Dwyer CM. Improving triplet lamb survival: management practices used by commercial farmers. Frontiers in Veterinary Science. 2024;11:1394484.
3. Soomro AA, Salam A, Steenbergen FV. 2025. Pastoralism in Balochistan: a quick insight. https://thewaterchannel.tv/thewaterblog/pastoralism-in-balochistan-a-quick-insight/
4. Kaleri RR, Kaleri HA, Leghari A, Solangi GM, Mangi RA, Chandio MA, Bhuptani DK, Khan IA, Mangrio ZA, Gopang MA, Baloch MI. Study on correlation estimates between carcass traits of sheep breeds of Baluchistan. Pure and Applied Biology. 2023;12(2):1242-1247.
5. Al-Thuwaini TM. The relationship of hematological parameters with adaptation and reproduction in sheep; A review study. Iraqi Journal of Veterinary Sciences. 2021;35(3):575-580.
6. Wanjala G, Bagi Z, Gavojdian D, Badaoui B, Astuti PK, Mizeranschi A, Ilisiu E, Ohran H, Juhas EP, Loukovitis D, Kawęcka A, Šveistienė R, Becskei Z, Strausz P, Kichamu N, Kusza S. Genetic diversity and adaptability of native sheep breeds from different climatic zones. Scientific Reports. 2025;15(1):14143.
7. Korelidou V, Simitzis P, Massouras T, Gelasakis AI. Hematological Parameters in Sheep: Variability, Determinants, and Applications in Flock Health Management. Animals. 2026;16(9):1295.
8. Očenáš P, Baloga M, Valko-Rokytovská M, Ivašková S. Determination of biochemical and metabolomic characteristics of sheep blood serum and their application in clinical practice. Life (Basel, Switzerland). 2025;15(7):1141.
9. Njidda AA, Shuai'bu AA, Isidahomen CE. Hematological and serum biochemical indices of sheep in Semi-Arid Environment of Northern Nigeria. Global Journal of Human Social Science, 14(2). Global Journal of Science Frontier Research: D Agriculture and Veterinary. 2014;14(2):49-56.
10. Bautista-Díaz E, Mezo-Solis JA, Herrera-Camacho J, Cruz-Hernández A, Gomez-Vazquez A, Tedeschi LO, Lee-Rangel HA, Vargas-Bello-Pérez E, Chay-Canul AJ. Prediction of Carcass Traits of Hair Sheep Lambs Using Body Measurements. Animals. 2020;10(8):1276.
11. Vishnu PG, Charitha VG, Praveeena G, Lakshmi JB, Satheesh K, Srilatha CH. Age-dependent phenotypic correlations of body weight and morphometric traits in Nellore brown sheep. International Journal of Veterinary Sciences and Animal Husbandry. 2026;11(1): 241-245.
12. Aslinia F, Mazza JJ, Yale SH. Megaloblastic anemia and other causes of macrocytosis. Clinical Medicine & Research. 2006;4(3):236–241.
13. Storz JF. Hemoglobin-oxygen affinity in high-altitude vertebrates: is there evidence for an adaptive trend?. The Journal of Experimental Biology. 2016;219(Pt 20):3190–3203.


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14. He L, Li X, Liu G, Cidan YJ, Ullah Q, Mushtaq R, Xiu Y, Sun G, Luosang DZ, Jiang N. Yak's resilience and adaptation to highaltitude stress. Pakistan Journal of Zoology. 2024;1-13.
15. Ahmad Z, Postigo JC, Rahman F, Hussain K, Altaf F. Changing mountain pastoralism and its impacts in the Hindu Kush Himalayan region: the case of Kushum, Pakistan. Nomadic Peoples. 2025;29 (2025):70–100.
16. Ingty T. Pastoralism in the highest peaks: role of the traditional grazing systems in maintaining biodiversity and ecosystem function in the alpine Himalaya. PloS One. 2021;16(1):e0245221.
17. Dias AVL, Messana JD, Granja-Salcedo YT, Alfonso YFM, Silva LG, Camargo KDV, Alves KLGC, Gonçalves PH, Reis RA, Berchielli TT. Efficiency of amino acid utilization in nellore cattle grazing low-quality forage supplemented with different sources of nitrogen. Life (Basel, Switzerland). 2023;13(8):1622.
18. Giri A, Tamgadge S. Red blood cells in health and disease. Journal of Microscopy and Ultrastructure. 2024;13(3), 130–136. https://doi.org/10.4103/jmau.jmau_70_23.
19. Villafuerte FC, Simonson TS, Bermudez D, León-Velarde F. High-altitude erythrocytosis: mechanisms of adaptive and maladaptive responses. Physiology. 2022;37(4):175-786.
20. Jacob N, Padodara RJ, Arya JS, Gajbhiye PU. WBC differential in Gir and Jaffarabadi animals at different physiological stages. Journal of Entomology and Zoology Studies. 2021;9(2):1015-1018.
21. Alberts B, Johnson A, Lewis J, et al.. Molecular Biology of the Cell. 4th edition. New York: Garland Science; 2002;2002. Lymphocytes and the Cellular Basis of Adaptive Immunity. Available from: https://www.ncbi.nlm.nih.gov/books/NBK26921/.
22. Baxmann AC, Ahmed MS, Marques NC, Menon VB, Pereira AB, Kirsztajn GM, Heilberg IP. Influence of muscle mass and physical activity on serum and urinary creatinine and serum cystatin C. Clinical Journal of the American Society of Nephrology. 2008;3(2):348–354.
23. Zhang X, Yang S, Chen J, Su Z. Unraveling the regulation of hepatic gluconeogenesis. Frontiers in Endocrinology. 2019;9:802.
24. Pesántez-Pacheco JL, Heras-Molina A, Torres-Rovira L, Sanz-Fernández MV, García-Contreras C, Vázquez-Gómez M, Feyjoo P, Cáceres E, Frías-Mateo M, Hernández F, Martínez-Ros P, González-Martin JV, González-Bulnes A, Astiz S. Maternal metabolic demands caused by pregnancy and lactation: association with productivity and offspring phenotype in high-yielding dairy ewes. Animals. 2019;9(6):295.
25. Kaneene JB, Miller R, Herdt TH, Gardiner JC. The association of serum nonesterified fatty acids and cholesterol, management and feeding practices with peripartum disease in dairy cows. Preventive Veterinary Medicine. 1997;31(1-2):59–72.
26. Vázquez-García JM, Álvarez-Fuentes G, Orozco-Gregorio HO, García-López JC, González-Hernández M, Rosales-Nieto CA. Energy supplementation during the last third of gestation improves mother-young bonding in goats. Animals. 2021;11(2):287.
27. Assan N. Determinants of birth weight and its size as an onset representative of growth potential in goat and sheep meat production. Agricultural Advances. 2020;9(5):522-536.
28. Rooyen IMV, Fourie PJ, Schwalbach LMJ. Relationship between pelvic and linear body measurements in Dorper ewes. South African Journal of Animal Science. 2012;42(5: Supplement 1):498-502.


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