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Evaluation of water adaptability of the Sirohi breed during different seasons under arid and semi-arid zones

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Abstract
Small ruminants, especially sheep and goats, possess an exceptional capacity for adjusting to challenging climatic circumstances and efficient water use, thus playing a substantial role in maintaining the economic and social status of rural agrarian economy, especially of arid and semi-arid regions. The present study was carried out to evaluate the water stress adaptation mechanisms followed by the Sirohi breed, with special emphasis on the water balance regulating hormones. The Antidiuretic, Aldosterone, and Angiotensin II concentrations in the plasma samples of the selected 10 healthy Sirohi breeds, each from the arid region and the semi-arid region were considered for the study during the summer season and the winter season. A significant ($p<0.05$) increase was observed in all the three hormones of interest from winter to summer. Also, a significant ($p<0.05$) variation was observed between the two agroclimatic zones for Antidiuretic, Aldosterone, and Angiotensin II hormone. The Sirohi goat breed consumed an average of 1.74 ±1.07 (L) and 1.68±0.76 (L) water per day in the arid zone and semi-arid zone respectively. Regardless of lower water intake, they are able to maintain their milk production in these arid and semi-arid zones. Therefore, the Sirohi breed, a well-adapted breed of hot and dry climates can be reared easily in coming decades of water scarcity while maintaining their productivity.

Keywords: Sirohi, water stress, antidiuretic hormone, aldosterone, angiotensin II

1. Introduction
India has an agrarian economy, with agriculture and allied sectors employing 70% of rural households. Animal husbandry, an essential component of the agricultural economy, employs 8% of the agricultural workforce especially the women workforce, and employs two-thirds of the rural population. Among the many animal populations, goat rearing accounts for a significant portion of the rural economy, particularly in the country's semi-arid, arid, and mountainous regions. Goats particularly the arid adapted breeds such as Sirohi, proficiently survive on low fertile plains under adverse environmental conditions using the available shrubs and trees and lower water intake.

The goat population in India accounts to 148.88 million in 2019 and exhibited a spike of 10.1% over the previous livestock census report and is expected to increase in the coming years [1]. The goat breeds are known for its high thermotolerance capacity when compared to other livestock species and is widely reared in harsh climatic environments throughout the world. The major reasons attributed to this thermotolerance capacity include low feed, and water requirements during harsh climatic conditions, smaller body size, and better feed conversion efficiency [2]. The thermoneutral zone provides the most favourable environmental conditions for animal performance [3]. Livestock with better productive features may produce poorly when the production environment is unfavourable due to a negative interaction between genetic merit and environmental variables [4].

Agricultural production especially livestock production has larger water footprints and is to be largely afflicted by heat stress and water scarcity. Water stress to be intensified in the coming years and may affect the production status and the survivability of the animal. Sirohi breeds is known for their survival in arid agroclimatic zones with less water availability. Given this, the current experiment sought to evaluate the water adaptability of the Sirohi breed under different agroclimatic conditions specifically arid and semi-arid zone.

2. Materials and Methods

2.1. Location and Environment

The current study was conducted at the National Dairy Research Institute, Karnal, India. The samples from the Sirohi breed belonging to the arid region were taken from Central Sheep and Wool Research Institute (CSWRI), Avikanagar, Rajasthan, and the samples from the Sirohi breed belonging to the semi-arid region were taken from Central Institute for Research on Goats (CIRG), Mathura, Uttar Pradesh. The experiment was conducted during two seasons of the year: winter (December to February) and summer (April to June).

2.2. Meteorological observation

During the experimental period, data from the weather station at CIRG and CSWRI on meteorological variables, temperature, and humidity were collected. Using the dry bulb and wet bulb thermometer readings as inputs, the Temperature Humidity Index (THI) was derived from the meteorological data using the following formula: THI= 0.72 x (Cdb + Cwb) + 40.6[5] where Cdb indicates dry bulb temperature and Cwb indicates wet bulb temperature.

2.3 Animals and experimental design

Ten healthy adult female goats belonging to the Sirohi breed, aged between 1.5- 2 years old were selected randomly from the arid and the semi-arid zone. All of the experiments were conducted in the field over two seasons (winter and summer) under the current management circumstances. The area's feeding and management practices were maintained, and no new/extra management or nutritional inputs were given to these animals during the experiment. The institutional animal ethics committee approved the conduct of research.

2.4 Blood sample collection

During the experimental period, blood samples were taken from the jugular vein of each animal (n=10) belonging to arid and semi-arid zones during two seasons namely the winter season and summer season. The collected blood samples were transferred into the laboratory under refrigerated conditions for further analysis and processing. Plasma samples obtained were stored under -20 °C until analysis.

2.5. Endocrinal variables

Aldosterone (ALD), Antidiuretic Hormone (ADH), and Angiotensin II (ANGII) were the endocrinal hormones of interest in this study. Species-specific ELISA kits for the above-said hormones were purchased from Bioassay Technology Laboratory.

2.6. Water intake

Separate pens were employed to hold the chosen groups of each breed of animal. Each pen received a measured amount of water in the morning and evening, independently. After drinking, the remaining water was measured along with the amount consumed.

Fig 1: Measurement of water intake in Sirohi breed

2.7 Statistical Analysis

The data from various experiments were given as mean SE. One-way and two-way ANOVA was used to determine significance. Software from SPSS Inc., Chicago, Illinois, USA, was used for all of the analysis. The results with a $p<0.05$ difference were judged statistically significant.

3. Result and Discussion

3.1 Climatic variables

The climatic variables observed during the experimental study are listed in Table 1. The temperature humidity index (THI) was calculated using the observed climatic variables.

Table 1: Relative humidity, Temperature, and THI during the experimental study

Location	Season	Relative humidity (%)	Average Temperature (°C)	THI
CIRG	Summer	25.5	39.4	84
	Winter	40.6	18.2	62
CSWRI	Summer	18.2	43.6	87
	Winter	38	14.4	60

Since the THI value is above 75 in summer season in both the arid and semi-arid zones, the animal experienced heat stress. THI value of winter season of both the regions also indicates

that the animal experiences cold stress during the winter season.

3.2 Endocrinal variables

The variations in the endocrinal variables of interest studied in this study during different seasons in different agroclimatic zones are presented in Table 2.

Table 2: Plasma endocrinal variables during different seasons in different agroclimatic zones

Location	CIRG		CSWRI	
Season	Winter	Summer	Winter	Summer
ALD (ng/L)	45.49^{ax} ±0.65	115.66^{bx} ±1.27	47.08^{ay} ±0.42	122.37^{by} ±0.49
ADH (ng/L)	1.84^{ax} ±0.13	9.24^{bx} ±0.25	1.87^{ay} ±0.03	10.02^{by} ±0.14
ANG-II (ng/L)	18.15^{ax} ±0.59	89.81^{bx} ±1.26	20.72^{ay} ±0.72	98.70^{by} ±0.79

The values are Mean ± SE, N=10

ALD: Aldosterone, ADH: Antidiuretic Hormone, ANG-II: Angiotensin II

^{abc} Bars with different superscripts are significantly different ($p<0.05$) between seasons

^{xyz} Bars with different superscripts are significantly different ($p<0.05$) between zones

The plasma ALD concentrations of Sirohi breeds varied significantly ($p<0.01$) between seasons. Between the two agroclimatic zones, also observed a significant difference in the ALD concentration that was statistically significant ($p<0.05$). During winters, the average plasma ALD concentration in the Sirohi breed of the semi-arid region was 45.49 ±0.65 ng/L while it was 47.08 ±0.42ng/L for the Sirohi goats native to the arid region. During the summer season, the concentration increased dramatically to 115.661.27 ng/L in semi-arid region Sirohi goats and to 122.370.49 ng/L in arid tract Sirohi goats. The arid tract adapted Sirohi goats had the biggest increase in aldosterone levels during the summer when compared to the semi-arid tract Sirohi goats.

The plasma ADH concentration in the Sirohi breed increased significantly ($p<0.01$) from winter to summer. A significant ($p<0.05$) difference in plasma ADH concentration in Sirohi goats was also reported between the arid and semi-arid region. The semi-arid region's Sirohi goats had an average plasma ADH content of 1.84±0.13ng/L in winter and 9.24 0.25ng/L in summer. During the winter, the Sirohi goats endemic to the arid tract had an average plasma ADH content of 1.87±0.03 ng/L, which increased dramatically to 10.02±0.14 during the summer season.

The ANG-II levels differed significantly ($p<0.01$) between the winter and summer seasons. The difference in plasma ANG-II levels in Sirohi goats between the two agroclimatic zones was statistically significant ($p<0.01$). During the winter, the average plasma ANG-II concentration of Sirohi goats from the arid zone was 20.72± 0.72 ng/L, whereas the ANG-II concentration of Sirohi goats from the semi-arid region was 18.15± 0.59 ng/L. During the summer, the ANG-II concentration increased to 98.70± 0.79 ng/L in arid-adapted Sirohi goats and to 89.81 ±1.26 ng/L in semi-arid-adapted Sirohi goats.

The plasma aldosterone concentrations found in this investigation are within the ranges previously reported in goats [6, 7]. ALD concentration was higher in Sirohi goats from the arid zone than in Sirohi goats from the semi-arid region. The increase in aldosterone concentrations is typically seen in hot, dry climates and is heavily regulated by seasons [8]. Water scarcity in the arid region may be ascribed to an increase in aldosterone and antidiuretic hormone levels in the body during the summer. Aldosterone aids in the significant reabsorption of sodium chloride and the release of potassium ions to maintain the body's salt balance. In times of heat stress and low water supply, aldosterone works on the salivary glands to prevent salt from being lost excessively. The greater amounts of plasma sodium seen in the Sirohi goats may explain the increased levels of aldosterone. The increased sodium levels reported in the native Sirohi goats allow these animals to conserve body salt concentration despite limited water intake and high temperature [9].

The plasma Antidiuretic hormone levels measured are within the reported ranges of (Shaham *et al.*, 1994; Achaaban *et al.*, 1992; Finberg *et al.*, 1978) [10-12].

The current study's findings on the increase in ADH are consistent with the findings of Olsson and Kristina (1989) [13]. Because Sirohi breeds have high ADH concentrations throughout the summer, they have an excellent water balancing economy in their body, limiting all conceivable routes of water loss from the body. The body's osmoreceptors are stimulated by the rise in plasma osmolality driven by dehydration, which results in the release of ADH and the maintenance of the body's water balance. To maintain the body's normal fluid dynamics, the increased ADH also triggers the reabsorption of water from the rumen, the gut, and other water sources. It was discovered that the Sirohi goat from the dry area had considerably higher ANG-II levels. The main element involved in the secretion of aldosterone is ANG-II. [14, 15], leading to increased ALD and vasopressin secretion.

3.3 Water intake

The average water intake of the Sirohi breed during different seasons under arid and semi-arid zone are depicted in Table 3.

Table 3: Average water intake of goats during different seasons

Location	CIRG		CSWRI	
Season	Winter	Summer	Winter	Summer
Water intake (L)	1.68^{a} ±0.76	1.95^{b} ±0.40	1.74^{a} ±1.07	2.01^{b} ±0.58

^{abc} Bars with different superscripts are significantly different ($p<0.05$) between seasons

The amount of water consumed by the Sirohi breed varied significantly ($p<0.01$) depending on the season. While Sirohi goats native to the arid zone consumed an average of 1.74 ± 1.07 (L) of water per day in the winter, the semi-arid region's Sirohi breed consumed an average of 1.68±0.76 (L). The water intake of Sirohi goats from semi-arid tract increased to 1.95± 0.40 (L) throughout the summer, whereas it increased to 2.01± 0.58 (L) for those from arid regions.

The Sirohi breed's water consumption fluctuated less dramatically throughout the seasons, a sign of effective water balance mechanisms. Wintertime decreases in water intake may be brought about by the abundance of lush food and the animal's slower metabolism. The Sirohi breed may have acquired adaptation mechanisms during years of survival in the area with limited water, which may be the cause of their decreased water consumption. According to Agnihotri and Rajkumar (2007) [16], the Sirohi breed typically produces

0.617 L of milk during 198 days of lactation. The Sirohi goats' capacity to maintain milk production even with lesser intake demonstrates their resilience to the dry environment.

4. Conclusion

Water stress conditions cause deleterious effects in maintaining the productivity status of the animal. Goats are those animals that tend to adapt and strive well in these water deficit areas even by feeding on poor quality feeds. Those breeds that have evolved and developed over several generations in these dry climatic zones, especially Sirohi breeds, have developed several water regulating mechanisms to strive under these water-scarce conditions. Therefore, the use of these adapted indigenous breeds is relevant for the future era of dramatic climatic change and water scarcity. Identification of those breeds that are withstanding water scarcity and the characteristics that help these breeds to overcome water deficit are to be studied in detail. The selection of suitable animal breeds is critical for long-term animal production in the coming era of climate change.

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