Effect of season and environment on growth in Osmanabadi goat

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Abstract

The present study was undertaken with the specific objective of evaluating the growth, physiological, and adaptability traits of Osmanabadi goats under farm and field conditions across different seasons, in order to assess their thermo-adaptive efficiency under varying management systems. This study was needed due to the economic importance of Osmanabadi goats in semi-arid Maharashtra, where they were reared under field conditions and exposed to environmental stressors such as heat, nutritional variability, and inconsistent management. Despite the recognized hardiness of Osmanabadi goats, integrated comparative studies across seasons and rearing systems are limited. There is a lack of data on seasonal variation in physiological stress indicators (RT, RR, PR), limited use of standardized adaptability indices (BCA, IHTC, DSI), and poor understanding of interactions between age, environment, and seasonal stress.

A total of 180 goats, comprising 80 from the Livestock Farm Complex & MAFSU Subcentre, Udgir, and 100 from field conditions, were categorized into growing (below 6 months) and adult (above 6 months) groups. Observations were recorded during summer (March–June), rainy (July–September), and winter (October–January) seasons. Growth parameters including body length, height at withers, chest girth, and body weight were measured, along with physiological responses such as rectal temperature (RT), respiration rate (RR), and pulse rate (PR). Seasonal variation significantly influenced growth, with higher body measurements observed during winter. While body dimensions were comparable between groups, field goats exhibited lower body weights. Physiological parameters remained largely stable, except for increased RR in field goats during summer, indicating heat stress. Adaptability assessment revealed that adult farm-reared goats exhibited better adaptability during summer based on BCA, whereas growing field goats showed reduced heat tolerance as indicated by IHTC. DSI values remained relatively constant across seasons and groups, indicating a stable adaptive profile.

Keywords: Osmanabadi goat; Growth parameters; Physiological parameters; Seasonal variation; Heat stress,

Introduction

Goats are a vital asset to rural communities, particularly in the arid and semi-arid regions of India, where they play a significant role in income generation and nutritional security. Among the indigenous breeds, Osmanabadi goats are especially valued for their adaptability, reproductive efficiency, and superior meat quality. These characteristics make them well suited for both commercial production systems and smallholder farming (Patil et al., 2014). Their ability to thrive under diverse climatic conditions highlights the need for a comprehensive evaluation of their physiological and morphological responses across different environments.

Goats reared under field conditions often travel longer distances for grazing, which may influence body conformation and musculoskeletal development. In contrast, restricted movement under farm conditions may lead to differences in structural growth patterns (Oke et al., 2025). Moreover, environmental management practices such as provision of shelter, shade, and controlled feeding in farm conditions support optimal growth, whereas fluctuating field conditions may result in variability in development (Sejian et al., 2018).

Seasonal variation plays a crucial role in regulating physiological and metabolic processes. Lakhani et al. (2018) demonstrated that seasonal changes influence endocrine functions, including hormones responsible for growth and development. They further reported that stress conditions may suppress anabolic processes, thereby adversely affecting biometrical growth. Similarly, Togoe and Minca (2024) observed that high ambient temperatures during summer increase maintenance energy requirements, thereby reducing the energy available for growth. Chronic heat stress can impair bone and muscle development, resulting in slower increases in structural measurements.

During favorable seasons, such as winter and post-monsoon periods, the availability of quality green fodder enhances skeletal growth and tissue development, leading to improvements in body length, height at withers, and chest girth. Conversely, during summer, poor forage quality and heat stress can limit growth and negatively affect these parameters (Singh et al., 2019).

Environmental and management conditions further influence physical development. Factors such as housing, access to shade, duration of grazing, and level of physical activity affect energy expenditure and musculoskeletal development. Increased locomotion under extensive grazing systems may alter structural growth patterns, while controlled feeding and proper shelter conditions promote more uniform and stable growth (Silanikove, 2000).

The present study was conducted in Udgir, Maharashtra, a region characterized by well-defined seasonal fluctuations. To improve the management and welfare of Osmanabadi goats, it is essential to assess the impact of seasonal variations on key growth and physiological parameters. Growth traits such as body length, height at withers, chest girth, and body weight serve as important indicators of overall physical development (Kumar et al., 2020). In addition, physiological parameters including respiration rate (RR), rectal temperature (RT), and pulse rate (PR) reflect the animal's response to environmental stress, particularly heat stress.

Furthermore, adaptability indices such as the Benezra Coefficient of Adaptability (BCA), Iberia Heat Tolerance Coefficient (IHTC), and Dairy Search Index (DSI) are widely used to assess an animal's ability to withstand climatic stress. These indices provide a quantitative measure of thermal adaptability in livestock (Marai et al., 2007).

The primary objective of the present study was to systematically evaluate and compare the growth, physiological, and adaptability traits of growing and adult Osmanabadi goats reared under farm and field conditions across different seasons (summer, rainy, and winter). The findings of this study are expected to contribute to the development of improved management strategies and to promote sustainable goat production under varying environmental conditions.

Materials and Methods

The research was carried out in Udgir and its surrounding areas in Maharashtra, located at approximately 18°23′46″ N latitude and 77°07′03″ E longitude (18.393400° N, 77.113144° E). A total of 180 Osmanabadi goats were included in the study, of which 80 were maintained at the Livestock Farm Complex (LFC) under the Maharashtra Animal and Fishery Sciences University (MAFSU), Sub-Centre at the College of Veterinary and Animal Sciences, Udgir, while the remaining 100 goats were selected from nearby villages under field conditions.

Under farm conditions, goats were housed in open sheds with brick flooring and asbestos roofing, provided ad libitum access to clean drinking water, and fed a balanced ration comprising roughage and concentrate as per standard feeding practices. Grazing was allowed for approximately 5–6 hours daily, and shade structures were provided to mitigate heat stress during summer. In contrast, goats reared under field conditions were maintained in open areas or under natural tree cover, with extended grazing periods exceeding 7 hours per day.

Animals were classified into two age groups: growing (<6 months) and adult (>6 months). Observations were recorded across three distinct seasons: summer (March–June), monsoon (July–September), and winter (October–January).

Physiological parameters recorded included respiration rate (RR), rectal temperature (RT), and pulse rate (PR). Growth measurements comprised body length (BL), chest girth (CG), height at withers (BH), and body weight (BW).

Adaptability was assessed using the following indices:

Iberia Heat Tolerance Coefficient (IHTC) (Rhoad, 1944)
IHTC = 100 − 10 (BT − 101)
where BT is the observed body temperature of the animal in °F. An IHTC value of 100 indicates optimal heat tolerance.

Benezra Coefficient of Adaptability (BCA) (Benezra, 1954)
BCA = (BT / 38.33) + (RR / 23)
where BT is rectal temperature in °C and RR is respiration rate per minute. A value close to 2.0 indicates better adaptability, while higher values suggest reduced thermal tolerance.

Dairy Search Index (DSI):
$DSI = 0.5 (X_1/X) + 0.2 (Y_1/Y) + 0.3 (Z_1/Z)$
where X_1, Y_1, and Z_1 represent observed rectal temperature (°C), respiration rate, and pulse rate, respectively, and X, Y, and Z denote their corresponding normal values. An increase in DSI value from 1 indicates decreased thermal adaptability.

Results & Discussion

Growth Parameters

Measurements of growth parameters across seasons and rearing conditions (farm vs. field) are summarized in (Table 1). In the summer, growing goats reared on the farm showed an average body length of 49.5 cm (±1.32), closely followed by field-raised counterparts at 49.0 cm (±0.77). Adult goats at the farm had a body length of 71.8 cm (±0.49), while those from the field measured slightly longer at 72.4 cm (±1.02). The average body height of growing goats was 45.0 cm (±1.25) at the farm and 45.3 cm (±1.01) in the field. For adults, the respective values were 66.4 cm (±0.52) at the farm and 65.7 cm (±0.99) in the field. The chest girth recorded in summer was 47.0 cm (±1.15) for growing farm goats, while adult goats showed 69.3 cm (±0.62). In terms of body weight, growing farm animals averaged 10.2 kg (±0.72), and adult animals reached 32.1 kg (±0.72). The body growth responses observed during summer reflect the animal's adaptive strategy to cope with thermal stress, where survival and physiological stability are prioritized over growth, thereby influencing physical development (Marai et al., 2007).

With the onset of the rainy season, a marginal increase was observed in these traits. The body length of growing farm goats increased to 52.6 cm (±1.25), while adult goats measured 73.0 cm (±0.07). The winter season recorded the highest values for most biometric traits. For instance, the body length of growing farm goats reached 56.64 cm (±0.54), while adult goats measured 73.9 cm (±0.54). Similarly, body weights peaked in winter, with adult goats averaging around 34.7 kg (±0.6).

These seasonal trends align with findings from previous research, which reported that goats tend to show improved growth performance during winter. This can be attributed to better forage quality and availability, along with more favorable (thermoneutral) environmental conditions during the cooler months (Kumar et al., 2010; Mandal et al., 2003; Gokhale et al., 2020).

Table:1 Mean ± SE of Growth measurements in growing and adult Osmanabadi goats during different season at Farm and Field

Parameters	Body Length (cm)				Body height (cm)				Chest girth (cm)				Body weight (Kg)			
Stage	Growing		Adult		Growing		Adult		Growing		Adult		Growing		Adult	
	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field
Summer	49.5 ± 1.32	49.0 ± 0.77	71.8 ± 0.49	72.4 ± 1.02	45.0 ± 1.25	45.3 ± 1.01	66.4 ± 0.52	65.7 ± 0.99	47.0 ± 1.15	46.3 ± 0.63	69.3 ± 0.62	68.2 ± 1.04	10.2 ± 0.72	9.84 ± 0.42	32.1 ± 0.72	31.9 ± 0.62
Rainy	52.6 ± 1.25	52.0 ± 0.72	73.0 ± 0.07	75.3 ± 0.82	48.5 ± 0.88	45.6 ± 0.71	67.9 ± 0.5	67.8 ± 0.89	51.1 ± 1.48	45.6 ± 0.68	69.8 ± 0.6	70.0 ± 0.76	12.8 ± 0.96	10.2 ± 0.44	33.0 ± 0.8	34.5 ± 0.9
Winter	56.64 ± 0.54	53.65 ± 1.3	73.9 ± 0.54	76.6 ± 0.65	46.9 ± 1.13	52.0 ± 0.72	69.2 ± 0.53	69.2 ± 0.61	52.32 ± 0.56	47.5 ± 1.13	71.5 ± 0.45	70.9 ± 0.68	14.2 ± 0.39	11.3 ± 0.39	34.7 ± 0.6	34 ± 0.86

While body length, height at withers, and chest girth did not significantly differ between growing and adult goats under farm and field conditions in the summer, body weight consistently remained lower in field-raised growing goats throughout all seasons. This difference may be due to variations in feed quality, management practices, and environmental stressors between the farm and field environments (Patil et al., 2014; Singh et al., 2016). The observed variations in growth parameters during summer can be attributed to the combined influence of environmental stress, nutritional availability, and physiological adaptation mechanisms (Marai et al., 2007; Silanikove, 2000). High ambient temperatures during summer impose thermal stress, which increases maintenance energy requirements for thermoregulation. As a result, a substantial portion of dietary energy is diverted toward maintaining homeostasis rather than supporting tissue accretion and skeletal growth, particularly in growing animals (Baumgard and Rhoads, 2013).

Physiological Responses

The physiological parameters respiration rate (RR), rectal temperature (RT), and pulse rate (PR) were monitored across all groups and seasons, and the results are summarized in (Table 2).

In the summer, the rectal temperature across both age groups and environments averaged around 39.5°C, with only slight variations between farm and field-reared goats. The respiration rate was approximately 35 breaths per minute in growing goats and about 37 in adults. These elevated values, especially in field animals, suggest a response to heat stress. This observation is supported by Vaidya et al. (2025), who noted that increased RR under field conditions is indicative of thermal stress a well-established physiological reaction in livestock coping with elevated ambient temperatures.

Heart rate (HR) remained stable across groups, averaging around 75 beats per minute, while pulse rate (PR) showed minimal variation, ranging from 74 to 75 beats per minute. During the rainy season, rectal temperature remained nearly constant at 39.4°C. There was a slight increase in respiration rate to about 36 breaths per minute. However, heart and pulse rates continued to remain steady at 75–76 and 74–75 beats per minute, respectively. In the winter, rectal temperatures declined marginally to approximately 39.2°C. Respiration rate showed more variability, ranging from 35 to 39 breaths per minute depending on age and rearing environment. Nonetheless, HR and PR stayed within consistent ranges of 75–76 and 74–76 beats per minute, respectively.

Across all three seasons, no significant changes were observed in rectal temperature, heart rate, or pulse rate between goats reared under farm and field conditions. However, an increased RR was clearly noted in both growing and adult goats kept in field conditions during the summer, likely a thermoregulatory mechanism triggered by high ambient temperatures. This is consistent with previous research highlighting respiratory rate as a primary indicator of heat stress in goats (Marai et al., 2007; Silanikove, 2000; Sejian et al., 2010). The seasonal patterns in physiological parameters represent a coordinated adaptive response, where respiratory adjustments serve as the primary mechanism for heat dissipation, while core physiological variables such as RT, HR, and PR are maintained within normal limits. This reflects the inherent ability of goats to prioritize thermal balance and physiological stability under varying environmental conditions (Sejian et al., 2010; Banerjee et al., 2015).

The general stability in most physiological parameters across varying seasons and environments indicates that Osmanabadi goats possess strong adaptability to climatic fluctuations. This aligns with earlier studies that have documented efficient thermoregulatory responses and high heat tolerance in indigenous goat breeds (Banerjee et al., 2015; Daramola et al., 2005).

Table: 2 Mean ± SE of Physiological responses in growing and adult Osmanabadi goats during different season at Farm and Field

Parameters	**Rectal temperature (^{0}C)**				**Respiration rate (Breath/m)**				**Heart Rate (Beats/m)**				**Pulse rate (Beats/m)**			
Stage	Growing		Adult		Growing		Adult		Growing		Adult		Growing		Adult	
	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field
Summer	39.5 ± 0.08	39.5 ± 0.06	39.2 ± 0.1	39.3 ± 0.06	35 ± 0.77	37 ± 0.79	31 ± 0.41	34 ± 0.80	75 ± 0.45	76 ± 0.58	74 ± 0.34	76 ± 0.54	75 ± 0.59	75 ± 0.67	73 ± 0.35	74 ± 0.40
Rainy	39.4 ± 0.08	39.4 ± 0.06	39.2 ± 0.1	39.2 ± 0.05	36 ± 0.62	36 ± 0.76	33 ± 0.28	33 ± 0.49	75 ± 0.86	76 ± 0.38	74 ± 0.4	74 ± 0.39	74 ± 1.12	75 ± 0.08	74 ± 0.2	73 ± 0.34
Winter	39.2 ± 0.09	39.6 ± 0.1	39.1 ± 0.1	39.1 ± 0.05	35 ± 0.74	35 ± 1.38	31 ± 0.42	33 ± 0.65	76 ± 0.64	76 ± 0.37	75 ± 0.2	76 ± 0.38	74 ± 0.82	76 ± 0.5	74 ± 0.27	74 ± 0.34

Adaptability Parameters

The adaptability of Osmanabadi goats was evaluated using three indices: the Benezra Coefficient of Adaptability (BCA), Iberia Heat Tolerance Coefficient (IHTC), and Dairy Search Index (DSI), as detailed in (Table 3). During the summer season, growing goats reared on farms exhibited an average BCA of 2.5 ± 0.03, while those under field conditions had a slightly lower value of 2.41 ± 0.03. Similar trends were observed in adult goats, with minor fluctuations across environments. Since lower BCA values are indicative of better adaptability (Benezra, 1954), adult goats maintained under farm conditions appeared to be more physiologically resilient to heat stress. The seasonal variation observed in adaptability indices reflects the physiological adjustments and coping mechanisms of goats in response to environmental stress, particularly heat load during summer.

The Benezra Coefficient of Adaptability (BCA) integrates rectal temperature and respiration rate, thereby reflecting the combined thermoregulatory effort of the animal. Animals capable of maintaining stable body temperature with minimal elevation in respiration rate exhibit better adaptability, indicating efficient energy utilization and reduced physiological strain (Benezra, 1954; Marai et al., 2007).

The IHTC values for growing goats during summer were approximately 2.0 in farm-raised goats and 2.3 in those raised under field conditions. Adult goats showed values of 2.4 on farms and 2.2 in fields. Lower IHTC scores signify higher heat tolerance (Bianca, 1961), which suggests that growing goats in the field were less adapted to summer heat. These findings corroborate earlier research indicating that young animals, especially under extensive systems, are more susceptible to environmental stress (Sejian et al., 2013; Vaidya et al., 2025).

The Iberia Heat Tolerance Coefficient (IHTC) reflects the animal's ability to maintain body temperature under heat stress conditions. Seasonal fluctuations in IHTC are primarily influenced by the animal's capacity to regulate internal temperature despite external thermal challenges. Younger animals are generally more sensitive to heat stress due to their immature thermoregulatory systems and higher metabolic demands for growth, which can compromise their ability to cope with elevated temperatures (Vaidya et al., 2025). Additionally, exposure to open environments, prolonged grazing, and limited access to shade can increase thermal load, thereby affecting heat tolerance (Sejian et al., 2013).

The Dairy Search Index (DSI), values were generally higher, indicating a good level of adaptability across both age groups and management systems. In summer, growing goats recorded DSI scores of 86.3 ± 2.05 under farm conditions and 78.8 ± 1.18 in field environments. Adult goats had slightly lower scores, though the seasonal variation remained consistent. The Dairy Search Index (DSI), which incorporates multiple physiological parameters, provides a composite measure of adaptability. Its relative stability across seasons suggests that goats maintain overall physiological balance through coordinated adjustments in multiple systems, even when individual parameters show variation. This indicates that adaptability is not governed by a single factor but rather by the integration of thermoregulatory, metabolic, and cardiovascular responses (Al-Dawood, 2017).

The BCA and IHTC indices revealed the influence of environmental and seasonal changes on the adaptability of Osmanabadi goats, particularly emphasizing the enhanced adaptability of adult goats under farm management during hot conditions. In contrast, the DSI remained relatively stable, reinforcing its value as a dependable measure for evaluating general adaptability and performance. These observations are in alignment with prior studies on heat stress resilience in indigenous goat breeds (Sejian et al., 2010; Banerjee et al., 2015). The Benezra Coefficient of Adaptability (BCA) and Dairy Search Index (DSI) exhibited highly significant correlations. Among the indices studied, the Iberia Heat Tolerance Coefficient (IHTC) was found to be the most reliable, as it demonstrated stronger statistical significance compared to the other indices. Based on these findings, rectal temperature emerges as the most dependable physiological parameter for assessing adaptability in Marathwadi buffaloes and Deoni cattle, as it forms a key component in the calculation of IHTC. (Vaidya et al., 2022).

Table: 3 Mean ± SE of Adaptability Parameters in growing and adult Osmanabadi goats during different season at Farm and Field

Parameters	**BCA**				**IHTC**				**DSI**			
Stage of Animals	Growing		Adult		Growing		Adult		Growing		Adult	
	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field	Farm	Field
Summer	2.5 ± 0.03	2.41 ± 0.03	2.0 ± 0.0	2.3 ± 0.03	86.3 ± 2.05	78.8 ± 1.18	88 ± 1.36	83 ± 1.21	1.1 ± 0.0	1.1 ± 0.0	1.0 ± 0.0	1.1 ± 0.0
Rainy	2.5 ± 0.03	2.34 ± 0.03	2.4± 0.0	2.2 ± 0.0	81.6 ± 1.53	85.03 ± 1.1	80.6 ± 0.7	85.8 ± 0.98	1.1 ± 0.0	1.1 ± 0.0	1.1 ± 0.0	1.1 ± 0.0
Winter	2.5 ± 0.03	2.39 ± 0.05	2.3 ± 0.01	2.2 ± 0.0	83.5 ± 1.64	86.3 ± 1.39	80.9 ± 0.52	86.2 ± 0.9	1.1 ± 0.01	1.1 ± 0.0	1.0 ± 0.0	1.1 ± 0.0

Conclusion

Seasonal changes affected growth, with peak body measurements and weights during winter, likely due to improved forage. Field-raised goats consistently showed lower body weights, reflecting the influence of management and environment. While rectal temperature, heart rate, and pulse rate remained stable, elevated respiration rates in field goats during summer suggested heat stress. BCA and IHTC indicated better heat adaptability in adult farm goats, whereas growing field goats were more vulnerable. DSI remained stable, highlighting consistent adaptability. From this study it may be concluded that, Osmanabadi goats showed strong resilience across seasons and environments, making them well-suited for diverse rearing systems in semi-arid regions.

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