Evaluating growth profiles and adaptability of Deccani sheep: insights for summer season management

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Abstract

A total of 162 Deccani sheep were selected from COVAS and the MAFSU Sub Centre, Udgir alongside 60 sheep from local fields studied during summer season, focusing on the growth and adaptability of Deccani sheep. The sheep were categorized into four distinct age groups: 0-2 months, 3-6 months, 7-11 months, and 12 months and above. The study spanned five years for the farm animals and one year for those in the field. Various biometrical parameters were measured, including body length, chest girth, height at withers, body weight, and surface area, which was calculated using Brody's formula. In terms of physiological responses, the study recorded parameters such as respiration rate, pulse rate, heart rate, and rectal temperature. To assess adaptability, the Adaptability Coefficients, namely the Beneziara Coefficients of Adaptability (BCA) and the Iberia Heat Tolerance Coefficients (IHTC), were calculated. Results indicated significant differences in growth and adaptability between farm and field Deccani sheep, with farm animals exhibiting superior growth metrics. However, the research also highlighted that both growing and adult sheep experience some level of stress, underscoring the necessity for tailored management strategies in both environments to optimize animal health and productivity.

Keywords: adaptation; heat stress; Beneziara Coefficients of Adaptability; Iberia Heat Tolerance Coefficients; Deccani Sheep

Introduction

The Deccani sheep is a breed native to the Deccan Plateau region of India, particularly found in states such as Maharashtra, Karnataka, and Andhra Pradesh. These sheep are well-adapted to the arid and semi-arid conditions of the region, making them resilient in diverse habitats. Characterized by a medium size, they have a well-proportioned body, a distinctive long shape, a rounded belly, and short legs. The fleece of Deccani sheep is coarse and typically white or light brown. This breed is known for its toughness and adaptability to harsh environmental conditions, including high temperatures and limited water supply. Deccani sheep play an integral role in local agriculture, contributing to the livelihoods of pastoral communities in the Deccan region through meat production while successfully adapting to the challenges of their habitat.

Overall, sheep farming not only supports the economic stability of rural populations but also promotes sustainable agricultural practices by utilizing resources efficiently (Rebollo-Morales *et al.* 2021). Given their adaptability and resilience, sheep can help bolster food security and improve the livelihoods of rural communities across India and beyond.

Livestock has become an important source of income and employment for the small landholders as India accounts 12.17% of sheep of the world's population (Sonavale *et al.* 2020) when animals are unable to loose excess metabolic heat by the different heat loss mechanisms (conduction, convection, radiation and sweating) they develop heat stress syndrome (Collier *et al.* 2019). Heat stress is indeed one of the most significant environmental challenges faced by livestock, particularly in regions with high temperatures and its impact on growth and development (Singh *et al.* 2016).

By effectively utilizing the Temperature Humidity Index (THI) and implementing various heat stress mitigation strategies, dairy farmers can protect their cattle from the adverse effects of extreme heat. This proactive approach not only helps maintain milk yield and growth performance but also safeguards the economic viability of dairy operations in hot climates. Sheep farming not only contributes to economic stability for small landholders but also promotes sustainable agricultural practices through efficient resource utilization. With India housing 12.17% of the world's sheep population, this sector plays a crucial role in enhancing food security and improving livelihoods.

Additionally, the significant challenge of heat stress in livestock, which can adversely affect their growth and development, especially in high-temperature regions. By employing the Temperature Humidity Index (THI) and implementing effective heat stress mitigation strategies, dairy farmers can protect their cattle from extreme heat. This proactive approach is essential for maintaining milk yield and ensuring the economic viability of dairy operations in hot climates, thereby supporting both animal welfare and agricultural productivity.

This study aims to provide valuable insights into the effects of heat stress on sheep, contributing to our understanding of their adaptability and informing strategies for managing livestock in increasingly challenging environmental conditions. By assessing both growth and physiological responses, we can develop comprehensive approaches to support sheep production sustainability in the face of rising temperatures.

The study of heat stress and its impact on sheep production is indeed critical for developing effective management strategies. As highlighted, identifying breeds with superior adaptability, such as the Deccani sheep, is essential for mitigating the adverse effects of heat stress. The physiological adaptations to heat stress, including heat load management and heat dissipation mechanisms, play a significant role in maintaining the health and productivity of these animals (Hyder *et al.* 2017). Indu *et al.* (2015) reported that the physiological determinants, such as rectal temperature, pulse rate, and respiratory rate, are vital indicators of how well sheep cope with heat stress. Understanding these parameters can help in assessing the overall well-being of the animals and their productive potential.

Given the challenges posed by decreasing grazing resources and the increasing demand for mutton and wool, focusing on the improvement of indigenous breeds like Deccani sheep is crucial. By harnessing the adaptive traits developed through natural selection, we can enhance their performance in a changing climate (Indu *et al*, 2015). Further research into the specific adaptations of Deccani sheep will provide valuable insights that can inform management practices, ultimately leading to improved health and productivity in ruminant systems. This approach not only supports the sustainability of sheep farming but also addresses the growing market demands effectively (Alameen *et al*, 2012).

The study focuses on the growth profile and adaptability of Deccani sheep during the summer season. It examines how these sheep cope with high temperatures and varying environmental conditions, highlighting their growth metrics such as weight gain and overall health.

Materials and Methods

The study conducted during the summer season (April-June) at COVAS, Udgir, located at longitude 77^0 07' 15'' E latitude 18^0 24' 0" N. A total of 162 sheep were observed from farm and 60 from field conditions. The average temperature recorded during the study was 38.5°C. The sheep were housed in open areas with brick floors and asbestos roofs, allowing them access to grazing for five to six hours daily. At the farm, they were provided with feed and water ad libitum, following standard feeding practices that included a mixture of concentrates and roughages. Adequate shade facilities were available to mitigate heat stress during the summer months. In field conditions, the sheep were kept in loose housing or under trees, with grazing opportunities extending beyond seven hours a day. Meteorological data were collected from an observatory at COVAS, Udgir, covering the years 2015-16 to 2019-20.

Biometrical measurements, including body length (BL), chest girth (CG), height at withers (BH), and body weight (BW), were recorded. Body surface area (BSA) was calculated using Brody's equation (1945). Physiological responses such as respiration rate, pulse rate, heart rate, and rectal temperature were measured to assess adaptability using two heat tolerance indices: Benezra's Coefficient of Adaptability (BCA) and Iberia Heat Tolerance Coefficient (IHTC). The data were statistically analyzed according to Snedecor and Cochran (1994), with mean values presented alongside standard errors in tabular format.

The Iberia Heat Tolerance Coefficient (IHTC) and Benezara's Coefficient of Adaptability (BCA) are both important metrics used to assess the thermal adaptability of animals.

1) Iberia Heat Tolerance Coefficient (IHTC) was estimated as suggested by Rhoad (1944).

IHTC = 100 – 10 (BT-101), Where, BT: Observed body temperature (0F) of the animal

Where, BT represents the observed body temperature of the animal in degrees Fahrenheit. An IHTC value of '100' signifies perfect adaptability to heat conditions, indicating that the animal is well-suited to its environment.

2) Benezara's Coefficient of Adaptability (BCA) was estimated as suggested by Benezara, (1954).

BCA= BT/38.33 + NR/23, Where BT: Rectal temperature (^{0}C) and NR: Respiration rate per minute. An increase in BCA from '2.0' indicates a reduction in thermal adaptability.

Results and Discussion

Biometrical parameters

The data on biometrical parameters are presented in Table 2. Body length (BL), body height, chest girth, body weight, and surface area were measured during the summer season for the farm animals during the years 2015-16 to 2019-20, and for the field condition, biometrical parameters were studied for one year, i.e., 2019-20 during the summer season.

Mean values of BL of Deccani Sheep at the age of 0-2, 3-6, 7-12 months, and one year and above were 57.8± 0.19, 71.1± 1.12, 80.8± 0.93 and 90.2± 1.16 cm respectively whereas, in the field condition were 54.8±0.4, 66.3±1.8, 83.1±1.5 and 86.1±0.4 cm respectively. The results indicate a slight decrease in body length for Deccani Sheep in field conditions compared to those raised on farms. This observation aligns with the findings of Bandewad *et al.* (2019), which reported average body lengths for Osmanabadi kids in different treatment groups (T0, T1, and T2) as 20.20 ± 1.07, 20.43 ± 0.92, and 20.14 ± 0.90 inches, respectively. This suggests that environmental factors associated with farming versus field conditions may influence the growth and development of these animals.

The mean CG values for Deccani Sheep in farms were 50.7±0.60 cm for ages 0-2 months, 59.8±1.02 cm for 3-6 months, 75.1±1.02 cm for 7-12 months, and 79.5±1.04 cm for those aged 1 year and above. In contrast, the corresponding values for field conditions were slightly lower at 48.4±1.0 cm, 56.1±1.0 cm, 73.5±1.3 cm, and 76.3±0.7 cm respectively. The study indicates a consistent trend where farm animals exhibit a slight increase in CG compared to their field counterparts across all age groups. Additionally, the findings align with previous research by Bandewad *et al.* (2019), which reported average CG measurements for Osmanabadi goats in different groups (T0, T1, and T2) as 20.92±1.03 inches, 21.16±0.95 inches, and 20.71±0.92 inches, respectively. The measurements for chest girth of Osmanabadi goat kids in the current investigation are consistent with earlier studies conducted by Nikam *et al.* (2012) suggesting reliability in the data collected.

Mean values of BH of Deccani Sheep at the age of 0-2, 3-6, 7-12 months, and 1 year and above were 48.6±1.02, 55.7±0.98, 59.9±1.16 and 66.4±0.84 cm respectively whereas in the field condition the values were 48.8±1.0, 52.0±1.1, and 55.5±0.9 and 64.8±0.8 cm respectively. These findings suggest a consistent trend of increased body height in farm conditions compared to field conditions, which may be attributed to factors such as nutrition, management practices, and environmental conditions. Additionally, the results align with previous studies,

Table 1. Avg. of meteorological data for the months April, May, June during 2015-16 to 2019-20.

S.No.	Parameters	April	May	June
1	Dry bulb temperature($0^{C)}$	31.2	32.7	26.0
2	Wet bulb temperature($0^{C)}$	22.0	23.2	24.0
3	Maximum temperature	39.6	38.5	34.4
4	Minimum temperature	25.0	23.2	21.5
5	Relative humidity	31	46.0	82.0
6	Vapour pressure	14.5	22.6	26.3
7	Dew point temperature($0^{C)}$	12.6	19.5	22.2
8	Sunshine period (hrs.)	10.0	8.	6.0
9	Evaporation	5.2	4.5	2.7
10	THI as per NRC (1971).	79	81	77

Table 2. Biometrical measurements in different age groups of Deccani sheep at farm and field during summer

Parameters	Body length (cm)				Chest girth (cm)				Body height (cm)				Body weight (Kg)				Surface area (m2)			
Groups /months	0-2	3-6	7-12	>12	0-2	3-6	7-12	>12	0-2	3-6	7-12	>12	0-2	3-6	7-12	>12	0-2	3-6	7-12	>12
2015-16	57.8	69.42	78.5	86.25	48.4	56	71.4	75.7	44.8	53.7	58.7	64.3	8.15	11.5	17.8	29.8	0.4	0.5	0.7	0.9
2016-17	58	71	83	93	51	60	75	81	50	53	56	65	9.3	12.1	21.6	31.5	0.5	0.5	0.8	0.9
2017-18	58	73	83	92	52	60	77	81	50	58	61	66	9.1	12.6	19.8	32.9	0.5	0.6	0.8	1.0
2018-19	57	67.9	79.5	89.6	51	61	75	79	48	56.6	61.3	68.1	9.3	13.1	20.4	32.6	0.5	0.6	0.9	1.0
2019-20	58	74	80	90	51	62	77	81	50	57	62.6	68.6	9.4	13.3	20.3	32.7	0.4	0.5	0.7	1.0
Mean ± SE Farm data	57.8 ±0.19	71.1 ±1.12	80.8 ±0.93	90.2 ±1.16	50.7 ±0.60	59.8 ±1.02	75.1 ±1.02	79.5 ±1.04	48.6 ±1.02	55.7 ±0.98	59.9 ±1.16	66.4 ±0.84	9.1 ±0.23	12.5 ±0.33	20.0 ±0.62	31.9 ±0.58	0.5 ±0.02	0.6 ±0.02	0.8 ±0.04	1.0 ±0.02
Field Data	54.8 ±0.4	66.3 ±1.8	83.1 ±1.5	86.1 ±0.4	48.4 ±1.0	56.1 ±1.0	73.5 ±1.3	76.3 ±0.7	48.8 ±1.0	52.0 ±1.1	55.5 ±0.9	64.8 ±0.8	8.5 ±0.2	11.7 ±0.2	21.6 ±0.5	29.2 ±0.7	0.4 ±0.0	0.5 ±0.0	0.8 ±0.0	0.9 ±0.0

Table 3: Avg. of physiological responses in Deccani Sheep at Farm and field during summer

Age (months)	Respiration rate (breath/min)		Pulse rate (beats/min)		Heart rate (beats/min)		Rectal temperature (^{0}C)	
	Farm	Field	Farm	Field	Farm	Field	Farm	Field
0-2	38 ±2.6	40 ±2.6	82±4.7	83±4.7	80±5.5	82±5.2	39.7±0.2	40.0±0.2
3-6	36 ±2.0	37 ±2.0	77±3.3	80±3.3	77±4.8	78±5.8	39.5±0.2	39.6±0.2
7-12	34 ±1.5	36 ±1.5	78±3.2	77±3.2	77±2.0	77±2.9	39.3±0.2	39.7±0.2
>12	32 ±1.5	34 ±1.5	74±1.6	74±1.6	76±2.7	77±2.7	39.3±0.2	39.5±0.2

Table 4: Avg. of adaptability parameters of Deccani Sheep at different age groups at farm and field during summer

Parameters	BCA						IHTC	
months/age groups	0-2 months	3-6 months	7-12 months	>1 year	0-2 months	3-6 months	7-12 months	>1 year
2015-16	1.6	1.5	1.5	1.4	99.8	97.6	97.6	97.0
2016-17	1.7	1.6	1.5	1.4	100.9	97.0	92.0	93.1
2017-18	1.7	1.6	1.6	1.5	94.2	93.7	93.7	94.8
2018-19	1.8	1.7	1.5	1.4	99.2	97.0	95.3	93.1
2019-20	1.8	1.7	1.6	1.5	99.8	97.6	97.0	95.3
Mean ± SE	1.7±0.0	1.6±0.0	1.5±0.0	1.4±0.0	98.8±1.1	96.6±0.7	95.1±1.0	94.7±0.7
Field Data	1.9±0.0	1.7±0.0	1.6±0.0	1.6±0.0	111±1.1	109.7±2.1	108.6±1.0	106.0±0.8

including those by Bandewad *et al.* (2019) regarding the height at withers of Osmanabadi kids, indicating a broader consistency in findings across different breeds and studies. The measurements for height at withers of Osmanabadi goat kids corroborate earlier reports by Jagdale, (2012) and Chaturvedi *et al.* (2010), reinforcing the reliability of the data presented.

Mean values of BW of Deccani Sheep at the age of 0-2, 3-6, 7-12 months, and one year and above were 9.1±0.23, 12.5±0.33, 20.0±0.62 and 31.9±0.58 kg respectively whereas, in the field conditions the values were 8.5±0.2, 11.7±0.2, 21.6±0.5 and 29.2±0.7 kg respectively. The study indicated that there were no significant decreases in body weight for Deccani Sheep raised in field conditions compared to those in farm condition. This finding aligns with the research conducted by Bandewad *et al.,* (2019), which reported average body weights for Osmanabadi kids as T0: 13.99 ± 0.79 kg, T1: 13.35 ± 0.64 kg, T2: 12.96 ± 0.48 kg These results suggest that while there are variations in body weight between different environments, the overall health and growth of the animals do not appear to be adversely affected in field conditions.

Mean values of the SA of Deccani Sheep at the age of 0-2, 3-6, 7-12 months, and one year and above were 0.5±0.02, 0.6±0.02, 0.8±0.04and 1.0± 0.02 m^2 respectively whereas, in the field condition 0.4±0.0, 0.5±0.0, 0.8±0.0 and 0.9±0.0 m^2 respectively. Despite observing variations in Surface Area across age groups in different rearing conditions, it is noteworthy that there were no significant decreases in body length of Deccani Sheep when comparing field conditions to farm animals. This indicates that while environmental factors may influence growth metrics like Surface Area, they do not necessarily result in adverse effects on body length. The results suggest a degree of resilience among Deccani Sheep to varying rearing conditions.

Physiological Responses

All the data of Physiological responses are presented in (Table 3) Respiration rate (breath/min), Pulse rate (beats/min), Heart rate (beats/min), and Rectal temperature (^{0}C) were measured during the summer season for five years from the farm animals (during the year 2015-16 to 2019-20). And for the field condition, the same physiological parameters were studied for one year (i.e., 2019-20) during the summer season.

The mean values of Respiration rate (breath/min) of Deccani Sheep on the farm at the age of 0-2, 3-6, 7-12 months, and 1 year and above were 38 ±2.6, 36 ±2.0, 34 ±1.5 and 32 ±1.5 breath/min respectively whereas, in the field condition the values were 40 ±2.6, 37 ±2.0, 36 ±1.5 and 34 ±1.5 breath/min respectively. The consistent pattern of elevated RR values in field conditions suggests that sheep in those environments are likely experiencing thermal stress. Indu *et al.* (2015) and Upadhyay *et al.*(2009) support this observation by linking increased RR to heat stress, citing it as a physiological response to maintain homeostasis through respiratory evaporative cooling. This response becomes more pronounced in higher ambient temperatures and humidity levels, which can be reflected in the elevated RR values across all age groups in field settings. Moreover, the literature indicates a strong correlation between increases in RR and the potential for thermal stress, which may serve as an early warning signal for livestock health. As noted by Nienaber *et al.* (2007), animals exhibiting increased respiratory rates are actively trying to dissipate heat, suggesting that environmental conditions significantly impact their well-being. The findings are further corroborated by Kumar *et al.* (2017), who observed similar respiratory rate increases in goats under heat stress, emphasizing a broader trend among livestock. This suggests a need for effective management strategies to mitigate heat stress, ensuring optimal animal health and productivity. In conclusion, the increased RR associated with field conditions points to the importance of monitoring physiological responses in livestock, particularly in the context of climatic variations.

The mean values of Pulse rate (beats/min) of Deccani Sheep in the farm at the age of 0-2, 3-6, 7-12 months, and 1 year and above were 82±4.7, 77±3.3, 78±3.2 and 74±1.6 beats/min respectively whereas, in the field condition 83±4.7, 80±3.3, 77±3.2 and 74±1.6 beats/min respectively. From the results of our study there was a slightly increased PR (presumably referring to pregnancy rate or another physiological parameter) in the 3-6 month group of field animals compared to farm animals is intriguing. It suggests that the environmental conditions in the field may play a role in influencing reproductive performance, possibly due to factors such as stress, nutrition, or management practices. In accordance to our findings Shaji *et al.* (2016) highlighted the significant relationship between heat stress and reproductive outcomes in Osmanabadi goats. Their results, indicating the highest PR in heat-stressed goats, underscore the necessity of monitoring heat stress as it could serve as an essential indicator for reproductive efficiency.

The mean values of Heart rate (beats/min) of Deccani Sheep on the farm at the age of 0-2, 3-6, 7-12 months, and 1 year and above were 80±5.5, 77±4.8, 77±2.0 and 76±2.7 beats/min respectively, whereas, in the field condition, 82±5.2, 78±5.8, 77±2.9 and 77±2.7 beats/min respectively. The findings of our study indicate a slight increase in heart rates (HR) in field animals when compared to farm animals. This elevation in HR could be attributed to the animals' exposure to heat stress, which is known to disrupt normal physiological functions, including circadian rhythms in heart activity. Previous research by Alhaidary (2004) supports this notion, showing

that average daily heart rates diminished under heat stress conditions, with control animals registering an average of 115.7 beats per minute, while those experiencing heat stress averaged 85.8 ± 11 beats per minute.

The mean values of Rectal temperature (°C) of Deccani Sheep in the farm at the age of 0-2, 3-6, 7-12 months, and 1 year and above age were 39.7±0.2, 39.5±0.2, 39.3±0.2 and 39.3±0.2 respectively whereas, in the field condition the values were 40.0±0.2, 39.6±0.2, 39.7±0.2and 39.5±0.2 respectively. Based on the findings, it appears that there were no significant differences in rectal temperature (RT) among the groups of animals observed in the study. This observation aligns with the work of Salio *et al.* (2017), who noted that RT trends are similar to respiratory rates (RR) in animals. Chandra Bhan *et al.* (2012) have similarly documented an increase in RT in animals subjected to high levels of heat stress, reinforcing the notion that RT serves as a valuable biological marker for assessing heat stress responses in domestic livestock. Similar trends in RT in Crossbred cattle were reported by Kadzere *et al.* (2002) stressed that even a minor elevation in RT, such as 1°C, can significantly impact livestock performance. This is further supported by findings from McManus *et al.* (2009), which suggest that RT is intrinsically related to various physiological traits linked to heat stress in farm animals. Additionally, it is well established that elevated temperatures and high relative humidity adversely affect the productivity of small ruminants, as highlighted by Silanikove (2000). The increase in RT serves as an indicator of an animal's struggle to regulate its body temperature in the face of summer heat stress, a phenomenon discussed by Marai *et al.* (2007).These findings emphasize the importance of monitoring RT in livestock as a means of evaluating their condition under heat stress, which has significant implications for their welfare and productivity.

Adaptability Parameters

The adaptability in Deccani Sheep were calculated by Benezra Coefficient of adaptability (BCA) and Iberia heat tolerance coefficients (IHTC) are presented in (Table 4)

The Mean values of the Benezra Coefficient of adaptability of Deccani Sheep at the age of 0-2, 3-6, 7-12 months, and one year and above groups were 1.7±0.0, 1.6±0.0 1.5±0.0and 1.4±0.0 respectively whereas, in the field condition the values were 1.9±0.0, 1.7±0.0, 1.6±0.0and 1.6±0.0 respectively (Table 4). Based on the findings presented, it appears that the adaptability coefficients determined through the Benezara Coefficient of Adaptability (BCA) method show varying levels of adaptability across different sheep groups and age ranges, with certain seasons influencing these coefficients as well. The initial statement notes that no significant differences were observed among the groups being studied, indicating a general consistency in the adaptability coefficients across the populations examined. This finding indicates a potential age-related influence on adaptability, which may correlate with metabolic and physiological factors. The research highlighted that adaptability coefficients approached 2 during the spring season, suggesting better adaptability during this time compared to the summer season. These results were agreement with Mandal and Tyagi (2008) reinforces the notion that thermo adaptability can significantly vary among breeds and is influenced by seasonal factors.

The Mean values of IHTC of Deccani Sheep at the age of 0-2, 3-6, 7-12 months and one year and above age were 98.8±1.1, 96.6±0.7, 95.1±1.0 and 94.7±0.7 respectively whereas, in the field condition the values were 111±1.1, 109.7±2.1, 108.6±1.0 and 106.0±0.8 respectively (Table 4). The heat tolerance coefficient is a value used to determine livestock's ability to adapt to hot conditions or heat resistance in each area (Mandal *et al.* 2021). The HTC and BCA scores of ewes in the inside placed treatment were higher than those in the outside placed treatment (Novi *et al.* 2023).This demonstrates that providing an outdoor pen can better meet the needs and wellbeing of ewes without compromising livestock adaptability to the environment.

Conclusions

Sheep body growth patterns vary between farm and field animals, with age playing a critical role. Body length, height, weight, chest girth, and surface area showed slight increases in farm animals but did not vary significantly in field-placed sheep.

The physiological responses of field sheep may increase slightly in lambs aged 0-2 months due to stress conditions; therefore, extra care should be taken with these lambs during the summer months under field conditions.

According to the adaptability calculated using the Benezara Coefficient of Adaptability and Iberia Heat Tolerance Coefficients, sheep were found to be adaptable to both farm and field conditions. However, field animal groups require additional attention and management to promote optimal growth and health. High temperatures can negatively impact animal comfort and productivity during the summer months.

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