Assessing growth patterns and adaptability of Osmanabadi goats during summer season

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Journal of Livestock Science (ISSN online 2277-6214) 16: 261-269
Received on 29/10/24; Accepted on 18/3/25; Published on 22/3/25
doi. 10.33259/JLivestSci.2025.261-269

Abstract

The study involving a total of 226 Osmanabadi goats from the Livestock Farm Complex at COVAS & MAFSU sub-center Udgir, along with 60 goats from the field, aimed to analyze the growth and adaptability profiles of these animals over different age groups (0-2, 3-6, 7-11, and 12 months and above). The research was conducted over five years for the farm animals and one year for the field animals. The biometrical parameters like body length, chest girth, height at withers, body weight, and surface area were measured. The physiological responses, viz respiration rate, pulse rate, heart rate, and rectal temperature, were recorded at both levels (i.e., farm and field). The adaptability coefficients, Beneziara Coefficients of Adaptability (BCA), and Iberia Heat Tolerance Coefficients (IHTC) were calculated. It was noticed that the body length, chest circumference, height at withers, body weight, and surface area increased at a faster rate in farm animals compared to field animals across both breeds. The findings for adaptability coefficients revealed that the IHTC indicated some stress in growing animals compared to adults, suggesting that younger animals may be more susceptible to environmental stressors. The findings highlight the differences in growth rates and physiological responses between farm and field environments, emphasizing the importance of environmental factors on the adaptability and performance of Osmanabadi goats. This research can inform management practices to enhance the welfare and productivity of goats in varying conditions

Keywords: adaptation; climate change; heat stress; Beneziara Coefficients of Adaptability; Iberia Heat Tolerance Coefficients; Osmanabadi Goats

Introduction

Osmanabadi goats are commonly found in the Osmanabad district of Maharashtra and is a large-sized animal that comes in various coat colors, though it is primarily seen in black with white or brown patches. This animal is utilized for both meat and milk production (Panda et al., 2016).

Climate change indeed presents significant challenges, impacting both ecological systems and economic stability. Among livestock, goats stand out for their adaptability to changing climatic conditions. Their ability to produce, survive, and reproduce effectively in the face of climate change makes them a resilient choice for farmers (Silanikove and Koluman, 2015). Goats can endure high levels of heat stress and require less water and feed compared to sheep which enhances their suitability for various environments (Aziz, 2010). This adaptability is crucial as we navigate the complexities of climate change and its effects on agriculture and food security.

Indigenous breeds have a higher thermo-tolerant capacity as compared to cross-bred and purebred animals. Genetic differences were established in the physiological adaptive capabilities of different breeds of goats (Souza et al., 2014). Heat stress significantly impacts livestock by altering both phenotypic and genotypic traits, which can be measured through various physiological responses, including respiratory rate (RR), rectal temperature (RT), skin temperature (ST), pulse rate (PR), and sweating rate (SR) (McManus et al., 2009). Research indicates that certain breeds exhibit varying levels of adaptability to heat stress. For instance, the Salem Black goat has been identified as more resilient to heat stress compared to the Malabari and Osmanabadi breeds (Pragna et al., 2017). Additionally, the Sirohi and Jhakrana goat breeds show increased RR compared to the Barbari breed, while the Barbari breed exhibits a higher RT than both Sirohi and Jhakrana breeds during heat stress, highlighting breed-specific adaptations (Kumar et al., 2017). In sheep, a study found that Avivastra sheep have higher RR and RT than Chokla sheep when exposed to heat stress (Ashutosh et al., 2000). The relationship between climate change and sheep production is intricate, as heat stress not only affects animal productivity but also leads to increased greenhouse gas emissions from livestock, which further exacerbates global warming (Savsani et al., 2015). Indeed, environmental temperature is a significant climatic variable that adversely affects livestock production. According to Reynolds et al., (2010), fluctuations in temperature can lead to stress in animals, which in turn can impact their health, growth, and overall productivity. Managing temperature and ensuring optimal conditions for livestock is essential for maintaining their well-being and maximizing production efficiency (Ogbuewu et al., 2016). The physiological adaptation of heat-stressed animals involves two key components. The first component is the heat load, which arises from various factors including metabolism, heat exchange, radiation, and convection with the surrounding environment. The second component is heat dissipation, which refers to the process of losing the accumulated heat primarily through sweat evaporation. This understanding is crucial for managing the well-being of animals under heat stress conditions (Indu et al., 2015). Animals have developed various adaptive mechanisms to manage the challenges posed by changing climatic conditions, as noted by Alameen et al., (2012). However, the combined effects of high temperature and humidity can negatively impact livestock, as highlighted by Key and Sneeringer (2014). To mitigate these adverse effects and enhance animal welfare, interventions such as foggers, fans, sprinklers, and anti-stress agents can be employed (Ambulkar et al., 2011; Anjali and Mahendra, 2010). The study focuses on evaluating adaptability indices and their correlation with physiological responses in buffaloes, specifically examining how these animals adapt to changing climatic conditions when microclimate alteration devices, such as foggers, fans, and feed additives, are utilized (Ramya et al., 2018). This research aims to provide insights into improving the resilience and welfare of livestock in the face of climate variability. The physiological determinants of adaptations to heat stress include rectal temperature (RT), pulse rate (PR), and respiratory rate (RR). These factors are critical in assessing how animals respond to elevated temperatures. When these physiological parameters are adversely affected, it can lead to a reduction in the productive potential of the animals, as noted in the study by Indu et al., (2015).

The present study aims to evaluate the effects of heat stress on the growth patterns and physiological responses of goats raised under farm and field conditions, with a focus on understanding their overall adaptability and body growth.

Materials and Methods

The study was conducted during the summer months of April to June in COVAS, Udgir, located at a longitude of 77° 07’ 15’’ E and latitude of 18° 24’ 0” N, and in the surrounding village of Nagalgaon, which has a longitude of 77.1126° E and latitude of 18.3943° N. During this period, the average temperature recorded was 38.5°C.

226 Osmanabadi goats in farm conditions and 60 goats in field conditions (i.e from Nagalgaon) were selected for the study. Inside the housing facilities, the goats were allowed to move freely and access grazing areas for six to seven hours each day, from 9 a.m. to 3 p.m. At the farm, the animals were provided with feed and water ad libitum, following standard feeding practices that included rations of concentrate mixtures and

roughages. Furthermore, adequate shade facilities were available to protect the animals from the heat during the summer season. In field conditions, the Osmanabadi goats were kept in loose housing or under trees, allowing them to graze for more than seven hours daily, from 10 a.m. to 3 p.m. Meteorological parameters were systematically recorded from the observatory at COVAS, Udgir, over the period from 2015 to 2020, ensuring comprehensive data collection for the study.

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

S.N.	**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

In the study, Biometrical measurements like body length (BL), chest girth (CG), and height at withers (HW) body weight (BW) were recorded, Body surface area (BSA) was calculated by Brody's (1945) equation, and physiological responses (respiration rate, pulse rate, heart rate, and rectal temperature) were recorded to determine the coefficient of adaptability by two heat tolerance indices, i.e., Benezra's Coefficient of Adaptability (BCA) (Benezra, 1954) and Iberia Heat Tolerance Coefficient (IHTC) (Rhoad, 1944) and data was statistically analyzed (Snedecor & Cochran, 1994). Mean values ± Standard Error are presented in tables.

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

Here, BT represents the observed body temperature of the animal in degrees Fahrenheit. An IHTC value of '100' indicates perfect adaptability to heat conditions, suggesting 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 (0C) and NR: Respiration rate per minute. An increase in BCA from '2.0' indicates a reduction in thermal adaptability.

Results and Discussion

Biometrical parameters

Body length (cm)

The body lengths (BL) of the animals measured in farms and fields are presented in (Table 2). The results indicate that there were no significant decreases in body length observed in the field conditions compared to the farm animals. These findings align with the research conducted by Bandewad et al., (2019), which reported average body length values 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 consistency suggests that both management systems support similar growth in body length among Osmanabadi goats.

Chest Girth (cm)

Mean values of Chest Girth (CG) of the animals measured in farms and fields are presented in (Table 2). The results indicate a slight increase in CG for farm animals compared to field animals in the age groups of 0-2, 3-6, and 7-12 months. However, no significant differences were observed in the CG of animals aged one year and above. Additionally, Bandewad et al., (2019) reported average CG values for Osmanabadi goats in treatment groups T0, T1, and T2 as 20.92 ± 1.03, 21.16 ± 0.95, and 20.71 ± 0.92 inches, respectively. The measurements for chest girth of Osmanabadi goat kids recorded in this study are consistent with findings from Nikam et al., (2012) and Gadade, (2004), further supporting the reliability of the data collected.

Body Height (cm)

Mean values of Body Height (BH) of the animals measured in farms and fields are presented in (Table 2). The results indicate that there were no significant decreases in body height observed in the field conditions compared to the farm animal groups. These findings are consistent with those of Bandewad et al., (2019), who reported the height at withers for Osmanabadi kids in treatment groups T0, T1, and T2 as 21.65 ± 0.93, 21.35 ± 0.97, and 21.22 ± 0.95 inches, respectively. Furthermore, the measurements for height at withers of Osmanabadi goat kids recorded in this study align with the reports from Jagdale (2012), and Chaturvedi et al., (2010), reinforcing the reliability of the data collected.

Body Weight (Kg)

Mean values of Body Weight (BW) of the animals measured in farms and fields are presented in (Table 2). The study found no significant differences in body weight between Osmanabadi goats raised in farm conditions compared to those in field conditions, indicating that field conditions do not adversely affect the weight gain of the goats. Rahman et al., (2015) reported that diets supplemented with green grass and tree forages led to improved weight gain, digestibility, and nitrogen balance in goats. They also highlighted that adding tree forages such as S. grandiflora, L. leucocephala, E. orientalis, and M. alba to goat diets can enhance growth performance. Similarly, Devasena and Rama Prasad (2014) indicated that farmers typically feed crop residues, particularly leguminous straws, which are rich in nutritional value and can serve as a significant feed resource during lean periods. The body weights for sub-groups under different conditions are similar, suggesting good adaptability of Osmanabadi goats to varying rearing environments. From the result of the study, no significant decreases in body weight were observed in the field conditions compared to farm animals. The results align with the findings of Bandewad et al., (2019), who investigated the body weights of Osmanabadi kids and reported average weights of 13.99 kg, 13.35 kg, and 12.96 kg across different treatment groups (T0, T1, T2). This similarity in results reinforces the conclusions drawn in the current study about the weight stability of Osmanabadi goats across different rearing conditions. The findings underscore the well-being and growth potential of Osmanabadi goats in both controlled (farm) and natural (field) environments, reinforcing their viability as a breed for various farming scenarios.

Surface Area (m2)

Mean values of Surface Area (SA) of the animals measured in farms and fields are presented in (Table 2). The surface area measurements for Osmanabadi goats were consistent across both farm and field conditions. No significant decreases in SA were observed in field conditions compared to farm environments. The results suggest that environmental conditions (farm vs. field) did not negatively impact the growth of surface area in these animals.

Physiological Responses

Respiration rate (breath/min)

Mean values of respiration rate (breath/min) of the animals measured in farms and fields are presented in (Table 3). The study presents intriguing findings regarding the respiration rates (RR) of Osmanabadi goats in different environmental conditions farm versus field. The collected data indicate that respiration rates were generally higher in field conditions across various age groups compared to farm conditions, particularly in the younger goats (0-2, 3-6, and 7-12 months). The findings suggest that the higher RR in field conditions may be attributed to thermal stress, which is consistent with existing literature that identifies an increase in RR as a key indicator of heat stress in livestock. Indu et al., (2015) support this notion by stating that a rise in RR can enhance evaporative cooling as animals attempt to regulate their body temperature. Further corroboration comes from Upadhyay et al., (2009), who noted that elevated RR is common in cattle facing high ambient temperatures and humidity. This study's results highlight that RR can serve as an early warning system for heat stress in goats. A significant increase in RR often signals an animal's effort to maintain homeostasis amid rising heat loads, as articulated by Nienaber et al., (2007). The observation that RR surges during the summer, confirming the goats' stress response, aligns with Kumar et al., (2017), who reported similar findings. From the study data suggests that Osmanabadi goats are more susceptible to heat stress in field conditions, as evidenced by their elevated respiration rates.

Pulse rate (beats/min)

Mean values of Pulse rate (beats/min) of the animals measured in farms and fields are presented in (Table 3). The findings of our study indicate that the pulse rate (PR) values were slightly elevated in field animals compared to farm animals. This observation aligns with the research conducted by Shaji et al., (2016), which reported significantly higher PR in heat-stressed Osmanabadi goats. Their study highlights the potential of PR as a useful indicator for assessing the level of heat stress in these animals. This suggests that environmental stressors may have a more pronounced effect on field animals.

Heart rate (beats/min)

Mean values of Heart rate (beats/min) of the animals measured in farms and fields are presented in (Table 3).The findings of our study indicate that heart rates (HR) were slightly elevated in field animals compared to those in farm settings. This increase in HR may be attributed to the animals' exposure to heat stress, which is known to induce circadian rhythmic changes in cardiac function. Alhaidary, (2004) reported a reduction in daily average HR under heat stress conditions, with values of 115.7 beats/min for the control group and 85.8±11 beats/min for the heat-stressed group. Furthermore, it has been observed that HR tends to peak during the hottest part of the day (around 15:00) in cattle, underscoring the impact of environmental stressors on animal physiology.

Rectal temperature (^{0}C)

Mean values of Rectal temperature (^{0}C) of the animals measured in farms and fields are presented in (Table 3). From the results of our findings, there was slight increase in RT in 0-2 month-old kids under field conditions compared to farm animals suggests that environmental factors may influence heat stress responses in younger goats. previous studies (Salio et al., 2017; Chandra Bhan et al., 2012) support the idea that RT is a useful indicator of heat stress with specific temperature ranges reported for different breeds and seasons. The

Table 2 Bio metrical measurement in different age groups of Osmanabadi goats at Farm and Field

Parameters	**Body length (cm)**				**Chest girth (cm)**				**Body height (cm)**				**Body weight (Kg)**				**Surface area (m2)**			
Groups /month	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	51.4	65.6	69.9	78.0	45.1	55.3	60.5	68.0	46.6	56.4	60.5	66.0	5.4	11.7	18.0	31.0	0.3	0.5	0.7	0.9
2016-17	55.0	68.0	76.0	87.0	46.0	52.0	65.0	73.0	43.0	52.0	63.0	71.0	5.7	12.7	21.2	34.0	0.3	0.6	0.7	1.0
2017-18	53.0	62.0	73.0	90.0	45.0	57.0	70.0	72.0	41.0	55.0	65.0	70.0	5.5	13.0	20.0	32.0	0.3	0.6	0.7	1.0
2018-19	46.0	53.0	75.0	86.0	45.0	55.0	71.0	71.0	43.0	52.3	67.0	70.0	6.0	12.9	18.0	33.0	0.4	0.6	0.7	1.0
2019-20	50.0	63.0	76.0	92.0	46.0	60.0	73.0	74.0	45.0	53.0	68.0	73.0	6.5	13.0	20.0	35.0	0.4	0.6	0.7	1.0
Mean ± SE	51.1 ±1.5	62.3 ±2.5	74.0 ±1.1	86.6 ±2.4	45.4 ±0.24	55.9 ±1.3	67.9 ±2.3	71.6 ±1.03	43.7 ±0.96	53.7 ±0.8	64.7 ±1.4	70.0 ±1.1	5.8 ±0.2	12.7 ±0.2	20.4 ±0.6	33.0 ±0.7	0.3± 0.02	0.6± 0.02	0.7 ±0	1.1 ±0.02
Field Data	50.4 ±0.5	62.1 ±2.1	70.8 ±0.7	90.7 ±1.3	42.3 ±0.8	51.9 ±1.9	64.3 ±1.4	73.9 ±1.2	45.3 ±0.5	52.3 ±1.3	64.2 ±1.5	76.5 ±0.8	5.4 ±0.2	12.7 ±0.7	20.8 ±0.4	31.3 ±0.7	0.3 ±0	0.5± 0.0	0.7 ±0	1.1 ±0

Table 3 Physiological responses in Goats at Farm and Field

Parameters	**Respiration rate (breath/min)**				**Pulse rate (beats/min)**				**Heart rate (beats/min)**				**Rectal temperature (0C)**			
Groups /month	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	30	32	36	34	85	72	79	75	87	73	72	77	39.6	39.8	39.6	39.8
2016-17	42	39	39	36	90	78	76	76	92	80	82	78	40.0	39.4	39.0	39.1
2017-18	32	37	39	35	85	78	80	74	89	79	79	75	39.2	39.2	39.2	39.7
2018-19	45	36	32	33	77	74	81	72	76	75	77	72	39.4	39.1	40.0	39.1
2019-20	40	32	30	37	74	72	70	75	75	72	75	77	39.3	39.6	39.7	39.9
Mean ± SE	38 ±6.5	35 ± 3.1	35± 4.0	35± 1.2	82± 6.5	75± 3.0	77± 4.4	74± 1.5	84± 7.8	76± 3.6	77± 3.8	76± 2.4	39.8 ±0.3	39.8 ±0.3	39.6 ±0.4	39.4 ±0.4
Field Data	41± 2.7	38± 2.0	36± 1.7	34± 1.8	85 ±5.1	79± 3.1	78± 3.0	76± 1.8	86± 8.0	80± 3.8	79± 3.8	77± 2.6	40.6 ±0.4	39.9 ±0.4	39.7± 0.3	39.6 ±0.4

Table 4.Adaptability coefficients of Osmanabadi Goat at different age groups

Parameters	**BCA**				**IHTC**			
months age groups	0-2	3- 6	7 - 12	>12	0-2	3- 6	7 - 12	>12
2015-16	2.3	2.4	2.6	2.5	77.2	73.6	77.2	73.6
2016-17	2.9	2.7	2.6	2.6	70	80.8	88	86.2
2017-18	2.4	2.6	2.7	2.6	84.4	84.4	84.4	75.4
2018-19	3.0	2.6	2.4	2.5	80.8	86.2	70.0	86.2
2019-20	2.8	2.4	2.3	2.6	82.6	77.2	75.4	71.8
Mean ± SE	2.7±0.3	2.6±0.2	2.6±0.1	2.5±0.2	79±5.7	80.4 ±5.2	79±7.2	78.6±7.0
Field Data	2.8±0.1	2.7±0.2	2.6±0.2	2.5±0.2	60±8.0	72±7.5	76±7.4	78±7.1

increase in RT during heat stress, even by 1 ºC or less, can significantly impact livestock performance, as pointed by Kadzere et al., (2002). This aligns with McManus et al., (2009), highlighting the relationship between RT and various physiological traits related to heat stress in farm animals. Our findings reinforce the understanding that high temperatures and humidity can negatively affect the productivity of small ruminants, as noted by Silanikove, (2000). The increased RT observed in animals exposed to heat stress indicates their struggle to maintain optimal body temperature, as discussed by Marai et al., (2007). These results underline the necessity for monitoring RT as a reliable biological marker for assessing heat stress in domestic livestock, particularly in varying environmental conditions.

Adaptability Parameters

Benezra Coefficient of adaptability

The mean values of the Benezra Coefficient of Adaptability (BCA) for animals calculated on farms and in fields are presented in (Table 4). Comparing these results to other studies suggests that Osmanabadi goats exhibit relatively high adaptability, especially in the younger age groups. Additionally, adaptability varies significantly across species and breeds, with different factors influencing the BCA in various studies. Nejad et al., (2017) reported that adaptation is the level of tolerance to survive and reproduce under extreme living conditions. The BCA values during the morning, midday, and afternoon were 2.77±0.04, 3.66±0.03, and 3.66±0.04, respectively, which are greater than our findings in goats. The increase in the BCA value of pregnant Kacang does during midday and afternoon can be attributed to the high humidity and air temperature during those times.

Iberia Heat Tolerance Coeficient

The mean values of IHTC for the animals calculated on farms and in fields are presented in (Table 4). The adaptability values derived from the IHTC method were consistently close to 100 across all age groups, indicating a high level of heat tolerance. Both IHTC and BCA can be used to assess the adaptability levels of individual animals in response to various environmental conditions, with normal values for IHTC and BCA in goats being 100 and 2, respectively (Araujo et al., 2017). An increase in the AC value of pregnant Kacang goats was observed during midday and in the afternoon, likely due to the high humidity and air temperature during those times. The BCA value recorded in this study was higher than the normal BCA value for goats, suggesting that the pregnant animals exhibited better adaptability (Qisthon and Hartono, 2019). Goats are known for their tolerance to water shortages and heat stress.

Conclusions

Biometrical Parameters: The measurements of body length, chest girth, body height, body weight, and surface area indicate that Osmanabadi maintain comparable growth in both farm and field. No significant decreases in these parameters were observed in field conditions, suggesting that Osmanabadi goats exhibit strong adaptability to varying rearing environments. Physiological Responses show notable variations between farm and field conditions. Increased respiration and heart rates in field suggest the goats may experience thermal stress, particularly during warmer months. Adaptability Parameters: The Benezra Coefficient of Adaptability (BCA) and Iberia Heat Tolerance coefficients (IHTC) values indicate that Osmanabadi goats demonstrate relatively high adaptability particularly in the younger age groups. These findings advocate for further research into the specific environmental factors affecting their physiological responses and adaptability, which could inform management practices aimed at optimizing welfare and productivity in varying climatic conditions.

Funding: This research received no external funding.

Acknowledgments: We wish to thank Associate Dean, COVAS, Udgir, MAFSU Nagpur for kind support during the experiment.

Conflicts of Interest: The authors declare no conflict of interest.

Statement of animal rights

The manuscript does not contain clinical studies or patient data.

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