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Effect of Heat Stress on Physiological Parameters in Madgyal Sheep

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The current study was carried out to assess the impact of heat stress on physiological parameters in Madgyal Sheep. To investigate this, sheep were exposed to 0,4 and 8 hrs heat of direct sunlight during grazing in 3 different Groups Viz A, B and C. The study was conducted on Day 0, Day 15 and Day 30 of the experiment to observe the effect of different duration of heat exposure on all physiological parameters. The temperature humidity index (THI) values duting the experimental period were found to be (76.28+-0.81) The results of the statistical analysis showed that there was no significant difference group wise and day wise in the Rectal temperature. However, the Respiration Rate, Pulse Rate and Heart Rate in Group wise comparison showed a significant

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difference (P<0.05) with increasing trend. In Day wise comparison of Respiratory Rate there was no significant difference at different days in Group A & B. However, there was a significance difference (P<0.05) in group C at different days with increasing trend. Pulse Rate and Heart rate Day wise comparison showed no significant difference at different days in Group A and C while there was a significant difference at different days in Group B with higher values at Day 15 and Day 30 as compared to at Day 0.

Keywords: Heat stress; sheep; physiological parameters.

1. INTRODUCTION

The Madgyal sheep breed is an indigenous breed in the Jat taluka in Sangli District. Abachiwari, Gholeshwar, Kunikonur, Madgyal, Pandozari, Sanamadi and Sonyal are prominent villages having typical Madgyal sheep [1]. The term Madgyal is derived from the Maharashtra distribution region of Madgyal village in Jat taluka in Sangli district.

A physiological assessment of an animal's capacity to withstand the vigorous climatic stress in warm conditions involves changes in body temperature and respiration rate [2]. The fluctuations in respiration rate (breaths/minute) are observed frequently in thermal stress [3]. The elevation in respiratory rate is an important heat stress thermoregulatory response and helps to dissipate heat through evaporative cooling [4]. Using shelters, fans, or evaporative cooling to change the environment is a key tactic to lessen the impact of heat stress on animals [5]. Goats graze in the open for most of the day in semi-intensive systems, making such techniques impractical. Furthermore, being a subtropical state, Maharashtra raises Sheep mostly by scavenging naturally occurring grasses. Thus, throughout the summer, they must deal with heat stress. However, nothing is known about how long-term or short term heat stress affects Madgyal Sheep in Maharashtra, India, in terms of behavior, physiology, biochemistry and productive indices.

Nevertheless, there are few inconsistent findings on how chronic heat stress affects physiological indicators in native sheep. Thus, it is imperative to investigate how heat stress affects Madgyal sheep's physiological and biochemical characteristics. Consequently, the goal of the current study is to ascertain how heat stress affects physiological parameters in Madgyal sheep.

These physiological processes include increased breathing, panting and radiating heat through the skin via radiation, conduction, convection or evaporation from the surface of the body to the surrounding air [6-9]. The rate of oxygen consumption increases in direct proportion to the temperature. It is assumed that the increase of the temperature of 10°C causes a two or even a threefold increase in oxygen consumption speed.

2. MATERIALS AND METHODS

The study involved eighteen Madgyal sheep older than two years of age and which were in good health with comparable body weights and kept under a semi-intensive farming system at Punyashlok Ahilyadevi Mendhi va Sheli Vikas, Prakshetra, Dahiwadi Taq: Man Dist. Satara Maharashtra. They were maintained on a comparable diet and almost under similar managemental practices during the research. Animals were divided into three groups: Group A: which was not exposed to heat (control group), Group B: which was subjected to direct sunlight for 4 hours per day(9:00 am to 1:00 pm) and Group C: which was exposed to direct sun light for 8 hours per day(9:00 am to 4:00 pm) while grazing.

The animals in Groups B and C were exposed to heat of direct sun light for 30 days during peak summer (March - June). For acclimatization, before the start of the experiment, these animals were exposed to heat for 07 days.

The variables related to weather such as the temperature and relative humidity were reported from which the temperature-humidity index (THI) was calculated by using the formula $(0.8\times Tdb) + [(RH/100) \times (Tdb-14.4)]+46.4$ in which Tdb is the dry bulb temperature and RH is relative humidity [10].

Physiological parameters like Rectal temperature (F), pulse rate (rates/min), respiration rate (breaths/min) and heart rate (rates/min) were measured daily by standard methods. Physiological parameters under study were subjected to statistical analysis using IBM SPSS

software by applying the Duncan's Multiple Range Test.

3. RESULTS AND DISCUSSION

Depending on the kind of tissue, acclimatization can take a few days to weeks. The heat stress response causes metabolic changes in a few days [11]. However, dehydration and severe heat stress cause physiological responses to alter instantly.

The average temperature humidity index (THI) value during the experimental period was (76.28±0.81). The THI value of zero day (72.27±0.00) was lowest, average of Day 1 to Day 15 (72.89±0.75) was higher than Day 0 and average of Day 16 to Day 30 was highest (79.50±0.81) with a significant difference ($P < 0.001$) during the study period. The average THI of entire experimental period was (76.28±0.81) which indicates that the Madgyal sheep in the study were under stress.

3.1 Rectal Temperature (°F)

Table 1 represents Group-wise and Day wise Mean± S.E. values of Rectal temperature during heat stress of Madgyal Sheep. The RT ranged from 101.47±0.22°F to 102.87±0.12°F, with an average of 102.14±0.06°F. Group C had the highest RT (102.87±0.12°F), followed by Group B (102.06±0.18°F) and Group A (101.47±0.22°F). Statistical analysis indicated no significant differences ($P<0.05$) among the groups, though there was an observable increasing trend in RT values.

The results of the statistical analysis showed that there was no significant difference group wise and day wise in the Rectal temperature. Present findings are in accordance with [12-15], who noted that rectal temperature was higher in heat-stressed animals than their control.

3.2 Respiration Rate (breath/min.)

Table 2 represent Group-wise and Day wise Mean± S.E. values of Respiration rate during heat stress of Madgyal Sheep. The RR ranged from 22.16±1.01 to 106.83±2.67 breaths/min, with an average of 78.59±1.79 breaths/min. Group B had the highest RR (106.83±2.67), followed by Group C (106.77±2.48) and Group A (22.16±1.01). Statistical analysis showed that in group wise comparison there was significant difference ($P<0.05$) in RR between Group A and Group B, as well as between Group A and Group C, but no significant difference between Group B and Group C.

In day wise comparison there was no significant difference ($P<0.05$) at different days in respiration rate (RR) within group A and B. Group C had significantly higher RR at 30 Days (111.66±1.54) compared to 15 Days (105.50±1.40) and 0 Days (103.16±2.95), with an increasing trend.

These findings are inconsistent with [16,17,13] who reported increased RR in heat-stressed animals. Conversely [18] found higher RR in winter than in summer.

The increase in RR under high temperatures is mainly due to moisture evaporation via the respiratory system [19]. present study suggests that the elevated RR in heat-stressed sheep helps to facilitate heat loss, as indicated by [3], who reported RR as a reliable indicator of heat stress.

Table 1. Group-wise and day wise mean± S.E. values of Rectal temperature during heat stress of Madgyal Sheep

	Day 0	Day 15	Day 30	Total
Control (Gr A)	101.86±0.24^{Aa}	101.41±0.24^{Aa}	101.15±0.99^{Aa}	101.47±0.22^{A}
4 hrs(Gr B)	102.08±0.23^{Aa}	102.00±0.17^{Aa}	102.11±0.18^{Aa}	102.06±0.18^{A}
8 hrs(Gr C)	103.03±0.16^{Ba}	102.66±0.10^{Aa}	102.93±0.04^{Aa}	102.87±0.12^{A}
Total	102.32±0.17	102.02±0.15	102.06±0.18	102.14±0.06

* *Superscripts with A B C in last column indicates group-wise comparison.*

** *Superscript with a b c in first three rows indicates day wise comparison.*

**** Similar superscripts indicates no significant different while dis-similar superscripts indicates significant differences at 5% level*

Table 2. Group-wise and day wise mean± S.E. values of respiration rate during heat stress of Madgyal Sheep

	Day 0	Day 15	Day 30	Total
Control (Gr A)	17.50±0.56^{Aa}	17.66±0.61^{Aa}	31.33±14.42^{Aa}	22.16±1.01^{A}
4 hrs (Gr B)	104.33±3.55^{Ba}	104.33±1.28^{Ba}	111.83±1.51^{Ba}	106.83±2.67^{B}
8 hrs (Gr C)	103.16±2.95^{Ba}	105.50±1.40^{Bab}	111.66±1.54^{Bb}	106.77±2.48^{B}
Total	75.00±9.96	75.83±9.99	84.94±10.26	78.59±1.79

* *Superscripts with A B C in last column indicates group-wise comparison.*

** *Superscript with a b c in first three rows indicates day wise comparison.*

**** Similar superscripts indicates no significant different while dis-similar superscripts indicates significant differences at 5% level*

3.3 Pulse Rate(rate/min.)

Table 3 represent Group-wise and Day wise Mean± S.E. values of Pulse rate during heat stress of Madgyal Sheep. The PR ranged from 77.11±1.57 to 86.27±1.69 rate/min, with an average of 81.35±0.85 rate/min. Group C had the highest PR (86.27±1.69), followed by Group B (80.66±2.00) and Group A (77.11±1.57). Statistical analysis revealed in group wise comparison there was a significant difference (P<0.05) between Group A and Group C, as well as between Group B and Group C, but not between Group A and Group B.

In Day-wise, comparison Group A showed no significant difference at different days. In Group B, PR values differed significantly between 0 Days (76.00±1.54), 15 Days (83.50±1.82), and 30 Days (82.50±1.78) without a clear trend. In Group C, there was no significant difference in PR values at 0 Days, 15 Days, and 30 Days.

These findings were corroborated with [13,15,20,21], who reported increased PR in heat-stressed animals. Significantly higher values of pulse rates in Madgyal sheep of group B and group C as compared to group A may be due to increased blood flow to the surface for heat dissipation, reflecting the animal's metabolic state and circulatory homeostasis [3,19].

3.4 Heart Rate(beats/min.)

Table 4 represent Group-wise and Day wise Mean± S.E. values of Heart rate (beats/min) during heat stress of Madgyal Sheep. The values ranged from 75.50±1.88 to 86.00±1.44 beats/min, with an average of 80.83±0.91 beats/min. In group wies comparison there was a significant difference (P<0.05) in the three all groups with increasing trend.

In Day-wise comparison at different days there was o significant different in group A & C. In group B the values of HR at different days were significantly different (P<0.05) with higher values at day 15 and day 30 as compared to day 0.

These findings were in consistent with [22-26] who reported higher HR in heat-stressed animals.

Table 3. Group-wise and Day wise Mean± S.E. values of Pulse rate during heat stress of Madgyal Sheep

	Day 0	Day 15	Day 30	Total
Control(Gr A)	79.16±1.75^{Aa}	76.16±1.27^{Aa}	76.00±1.54^{Aa}	77.11±1.57^{A}
4 hrs(Gr B)	76.00±1.54^{Aa}	83.50±1.82^{Bb}	82.50±1.78^{Bb}	80.66±2.00^{A}
8 hrs(Gr C)	88.00±2.20^{Ba}	85.00±1.34^{Ba}	85.83±1.44^{Ba}	86.27±1.69^{B}
Total	81.05±1.59	81.55±1.23	81.44±1.31	81.35±0.85

* *Superscripts with A B C in last column indicates group-wise comparison.*

** *Superscript with a b c in first three rows indicates day wise comparison.*

**** Similar superscripts indicates no significant different while dis-similar superscripts indicates significant differences at 5% level*

Table 4. Group-wise and Day wise Mean± S.E. values of Heart rate (beats/min) during heat stress of Madgyal Sheep

	Day 0	Day 15	Day 30	Total
Control (Gr A)	77.16±2.00^{Aa}	73.83±1.90^{Aa}	75.50±1.78^{Aa}	75.50±1.88^{A}
4 hrs(Gr B)	80.33±1.81^{Aa}	81.50±1.80^{Bb}	81.16±1.79^{Bb}	81.00±1.71^{B}
8 hrs(Gr C)	85.33±1.35^{Ba}	85.83±1.44^{Ba}	86.83±1.70^{Ca}	86.00±1.44^{C}
Total	80.94±1.25	80.38±1.52	81.16±1.47	80.83±0.91

** Superscripts with A B C in last column indicates group-wise comparison.*
*** Superscript with a b c in first three rows indicates day wise comparison.*
**** Similar superscripts indicates no significant different while dis-similar superscripts indicates significant differences at 5% level*

4. CONCLUSION

The Physiological parameters such as Rectal temperature, Pulse rate, Respiration rate and Heart rate were elevated in heat stressed groups during the study in an attempt of thermo-adaptability of Madgyal Sheep. Effect of THI on these physiological parameters was more as compared to duration of exposure.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ETHICAL APPROVAL

The research was approved by the Institutional Animal Ethics Committee (IAEC) [Protocol No IAEC11/23/KNPCVS/2024].

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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