

Effect of altered microclimate on alleviating heat stress in sheep

RAVIKANTH JETTY^{1✉}, S SREEDHAR², CH VENKATA SESHIAIAH² and P KAVITHA²

N.T.R College of Veterinary Science, Gannavaram, Andhra Pradesh-521 102, India.

Received: 06 December 2023; Accepted: 27 March 2025

ABSTRACT

The present research was conducted to study the effect of fan and foggers on Temperature Humidity Index (THI) and physiological responses in Nellore brown sheep during summer. Twenty ewes of age 3-5 years from sheep unit of Livestock Farm Complex of NTR college of Veterinary Sciences, Gannavaram were divided into 2 groups of each 10 ewes each in a completely randomized design on the basis of body weight. The animals in the group-I were considered as control whereas the animals in the group-II were equipped with fan and foggers for modification of microclimate in the shed. Data on temperature-humidity index and various physiological responses were recorded and analysed statistically. Analysis revealed that, the day average THI was significantly higher in control group (85.67 ± 0.40) as compared to treatment group (83.45 ± 0.30). No significant difference was observed in the morning THI whereas in evening THI significant difference was observed between control (86.84 ± 0.51) and treatment group (83.35 ± 0.36). The average rectal temperature, average respiration rate and average pulse rate was significantly lower in treatment group (102.41 ± 0.04 , 41.61 ± 0.81 , 87.94 ± 0.52) as compared to control group (103.02 ± 0.05 , 57.91 ± 1.29 , 95.42 ± 0.55). No significant difference was observed in the morning recorded physiological responses. Therefore, it can be concluded that microclimate modification with the help of foggers and fans is a means to protect the animals from thermal stress under intensive sheep production system during the summer season.

Keywords: Fans, Foggers, Heat stress, Nellore brown sheep, Physiological responses, Summer, Temperature-humidity index

Climate change is considered to be a main risk for viability and sustainability of livestock production in tropical and sub-tropical regions (Gaughan *et al.* 2009). Temperature, humidity, and radiation fluctuations are identified as potential risks in the growth and production of all livestock species. During summer, environmental temperatures increase, causing heat stress (HS) in animals. Among the stressors, heat stress has been the primary concern in decreasing livestock production in tropical, subtropical, and arid conditions (Silanikove *et al.* 1997).

Sweating, high respiration rate, vasodilation with increased blood flow to the skin surface, high rectal temperature, reduced metabolic rate, efficiency of feed utilization and altered water metabolism are the physiological responses that are associated with the negative impacts of heat stress on production and reproduction in sheep (West *et al.* 1999). The animal employs several adaptive mechanisms to maintain homeostasis through behavioural, physiological, neuroendocrine, cellular and molecular responses to cope up with the existing climatic condition (Sejian *et al.* 2017). The intensity of heat stress may be determined by calculating the Temperature Humidity Index (THI), which is one of the most widely

used indices for measuring the effect of heat stress on livestock productivity. THI is used to evaluate heat stress through combining the effects of temperature and relative humidity (RH) into a single value. There are different approaches for managing heat stress in livestock. One of the most important approaches for decreasing the effect of heat stress in livestock is shelter management. Microclimate modification devices like foggers and fans could help in minimizing heat stress in shelters and provides comfort to the animals. As fog droplets are emitted, they are rapidly circulated into the air stream of the fan, where they quickly evaporate. Animals are cooled when cooled air is pushed over them and when they inspire cooled air. The present study was conducted to study the effect of these microclimate modifiers on THI and physiological states of Nellore brown sheep.

MATERIALS AND METHODS

Place of study: The present study was conducted on Nellore brown sheep at sheep unit, livestock farm complex (LFC) of NTR College of Veterinary Science, Gannavaram, Krishna district, Andhra Pradesh, for a period of three months (April 2023 to June 2023) during summer season. The farm is situated at an elevation of 12 meters above sea level on 81° longitude and 16.5° latitude. The maximum temperature goes up to 49°C during summer season.

Present address: ¹Jayabhushan Agro Industries Pvt.Ltd, ²N.T.R. College of Veterinary Science Gangavaram. ✉Corresponding author email: munna.j87@gmail.com

Experimental design and animals: Twenty adult Nellore brown females of 3-5 years of age were selected from Livestock Farm Complex (LFC). The animals were divided into two equal groups of each 10 ewes in a completely randomized design on the basis of body weight. All the experimental sheep were reared under intensive rearing system having a cement concrete floor and side walls of height 3 feet and 9 inches thickness, closed area (165 sq.ft), open area (242 sq.ft) and corrugated galvanized iron sheets were used as roofing material at a height of 11 ft from the floor.

The sheep in Group I were considered as control group without any microclimate modification, while the sheep in Group II were provided with fan and foggers and considered as treatment group. One 52 inch ceiling fan with a 75 watt output is kept 10 feet above the floor. Two foggers were kept at a height of 9 ft. from floor and were allowed from 11.00 A.M. to 5.00 P.M. daily with a function of 2 minutes on and 3 minutes off by using single phase (230 Vac) analog cyclic timer. Plastic Foggers (BLUESTAL Agri equipment) having 4-way anti-leak technology with nozzle size 0.5 mm and droplet size-80-100 micron are used in experimental houses. With the help of digital hygrometer placed at a height of 2 feet from the ground ambient temperature (°F) and ambient relative humidity (%) were recorded from the shed twice a day i.e., at 8.30 A.M. and 2.30 P.M. by using digital hygrometer (HTC-1). Temperature accuracy and humidity accuracy of hygrometer were 32.9°F (32°F-104°F) or +1% and +3% RH (50%-80%) or +5%, respectively. To estimate the heat stress of the sheep, Temperature-Humidity Index was calculated by using the following formula, (LPHSI, 1990).

$$THI = T(db) - \{(0.55-0.55RH)(T(db) - 58)\}$$

Where,

T (db) = Dry bulb temperature (°F)

RH = Relative humidity (%)

Physiological responses: The physiological responses such as rectal temperature, respiration rate and pulse rate were recorded weekly at 8.00 A.M. in the morning and 4.00 P.M. in the evening. The rectal temperature (RT) was recorded accurately by clinical thermometer inserted into rectum approximately 6 to 7 cm deep ensuring that the thermometer bulb was left in contact with the rectal mucosa for one minute. The observations were recorded in degree Fahrenheit (°F). The respiration rate (RR) was recorded by observing flank movement for one minute in which each inward and outward movement of the flank was counted as one complete respiration. The respiration rate was expressed as breaths per minute. Pulse rate (PR) was measured by palpating the femoral artery on inner side of the hindlimb approximately one-third of the way down with minimum disturbance to the animals. The pulse rate was expressed as beats per minute.

Statistical analysis: The data was subjected to two sample *t*-test using SPSS IBM, version 22.0 statistical package.

RESULTS AND DISCUSSION

Temperature-humidity index: The morning and evening temperature, relative humidity and THI for both the groups are presented in the Table 1 and the graphical representation of weekly average THI data was presented in fig. 1. Overall morning temperature (°F) were 87.98±0.20 and 87.51±0.19 and evening temperature (°F) were 97.38±0.31 and 91.87±0.18 for control and treatment shed, respectively. Results indicated significantly ($p<0.05$) lower evening temperature (°F) in treatment shed as compare to control shed. Similar to present findings, Verma *et al.* (2015) reported lower temperature under cooling system with forced ventilation in Murrah buffalo heifers. Use of sprinkler with fans helped to ameliorate the thermal stress during heat stress in beef cattle (Gaughan *et al.* 2010). The lowered evening temperature in treatment group might be due to provision of cooling system and due to fast air exchange through forced ventilation (fogger with fans).

The overall mean morning THI values for control shed and treatment shed were 84.52±0.39 and 83.55±0.46, respectively. No statistical difference was found between the two groups. The mean evening THI values for control shed and treatment shed were 86.84±0.51 and 83.35±0.36, respectively. The mean evening THI value for treatment shed was significantly ($p<0.01$) lower as compared to

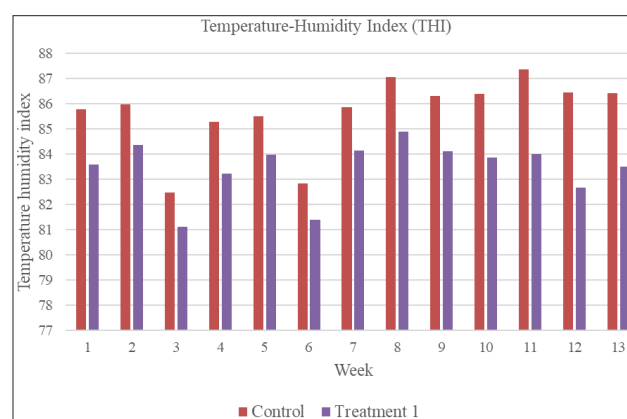


Fig. 1. Effect of microclimate modification on average temperature humidity indices (THI) in Nellore brown sheep

Table 1. Effect of microclimate modification on Temperature-humidity index (THI) in Nellore brown sheep.

Parameter	Group I	Group II
Overall morning temperature (°F)	87.98±0.20 ^a	87.51±0.19 ^a
Overall evening temperature (°F)*	97.38±0.31 ^a	91.87±0.18 ^b
Overall morning relative humidity (%)	73.09±1.31 ^a	74.11±1.32 ^a
Overall evening relative humidity (%)*	41.76±1.39 ^a	49.64±1.23 ^b
Overall morning THI	84.52±0.39 ^a	83.55±0.46 ^a
Overall evening THI **	86.84±0.51 ^a	83.35±0.36 ^b
Overall day average THI**	85.67±0.40 ^a	83.45±0.30 ^b

Means with different superscripts in a row differ significantly
* ($p<0.05$) ** ($p<0.01$)

control group. The mean day average THI values for control shed and treatment shed were 85.67 ± 0.40 and 83.45 ± 0.30 , respectively. Significantly ($p < 0.01$) lower day average THI was noticed in the treatment group as compared to the control group. The results indicates that the sheep in control group were under severe heat stress whereas the sheep in treatment group were under moderate heat stress. An increase in THI was observed in the evening than that of morning because of higher ambient temperature in the evening. The temperature in all the shed was lower in the morning because there is no radiation effect from the floor and surrounding concrete structures. However, the THI is higher in the evening, due to progress of ambient temperature coupled with radiation effect. Present findings were in accordance with earlier reports of Khongdee (2008), Chandra *et al.* (2012) Seerapu *et al.* (2015), Sinha *et al.* (2018), Savaliya *et al.* (2019), Sinha *et al.* (2019) and Goswami (2021) who reported lower THI in microclimate altered group with foggers and fans in cattle and buffaloes. Reduction of THI values might be attributed to evaporative cooling effect caused by the provision of foggers and fans in treatment group.

Physiological responses: The physiological responses of the treatment and control sheep is presented in Table 2. The mean morning values of rectal temperature, respiration rate and pulse rate in control and treatment group were 102.21 ± 0.05 and 102.18 ± 0.04 ; 35.07 ± 0.81 and 34.39 ± 0.80 ; 85.69 ± 0.55 and 85.35 ± 0.55 , respectively. No significant difference was observed in the mean morning values of rectal temperature respiration rate and pulse rate in control and treatment group. In the evening the mean rectal temperature was observed as $103.81 \pm 0.07^\circ\text{F}$ and $102.63 \pm 0.04^\circ\text{F}$ in control and treatment groups, respectively. The average mean rectal temperature

Table 2. Effect of microclimate modification on physiological responses in Nellore brown sheep

Parameter	Group I	Group II
Mean rectal temperature morning ($^\circ\text{F}$)	102.21 ± 0.05^a	102.18 ± 0.04^a
Mean rectal temperature evening ($^\circ\text{F}$) **	103.81 ± 0.07^a	102.63 ± 0.04^b
Mean rectal temperature average ($^\circ\text{F}$) **	103.02 ± 0.05^a	102.41 ± 0.04^b
Mean respiration rate morning (breaths/min)	35.07 ± 0.81^a	34.39 ± 0.80^a
Mean respiration rate evening (breaths/min) **	80.74 ± 1.94^a	48.83 ± 1.01^b
Mean respiration rate average (breaths/min) **	57.91 ± 1.29^a	41.61 ± 0.81^b
Mean pulse rate morning (beats/min)	85.69 ± 0.55^a	85.35 ± 0.55^a
Mean pulse rate evening (beats/min) **	105.16 ± 0.67^a	90.53 ± 0.59^b
Mean pulse rate average (beats/min) **	95.42 ± 0.55^a	87.94 ± 0.52^b

Means with different superscripts in a row differ significantly * ($P < 0.05$) ** ($P < 0.01$)

values in control and treatment groups were recorded as $103.02 \pm 0.05^\circ\text{F}$ and $102.41 \pm 0.04^\circ\text{F}$, respectively. Graphical representation of average rectal temperature at weekly intervals in Nellore brown sheep was presented in fig. 2. Statistical analysis revealed that the mean evening and average mean rectal temperature of control group were significantly ($p < 0.01$) higher than that of treatment group. The probable reason might be due to evaporative cooling effect caused by the provision of foggers and fans in treatment group. These results were in agreement with those reported by Seerapu *et al.* (2015) and Sinha *et al.* (2019) who stated that foggers and fans decreased rectal temperature in buffaloes and cows respectively. Ranjana *et al.* (2017) and Savaliya *et al.* (2019), however, had earlier reported non-significant difference in rectal temperature in cattle, and due to foggers.

Graphical representation of average respiration rate at weekly intervals in Nellore brown sheep was presented in fig. 3. The mean respiration rate (breaths/min) recorded in Nellore brown sheep during evening was 80.74 ± 1.94 and 48.83 ± 1.01 breaths/min in control and treatment groups, respectively. The average mean respiration rate values in control and treatment groups were recorded as 57.91 ± 1.29 and 41.61 ± 0.81 breaths/min, respectively. The evening and day average mean respiration rate control and treatment

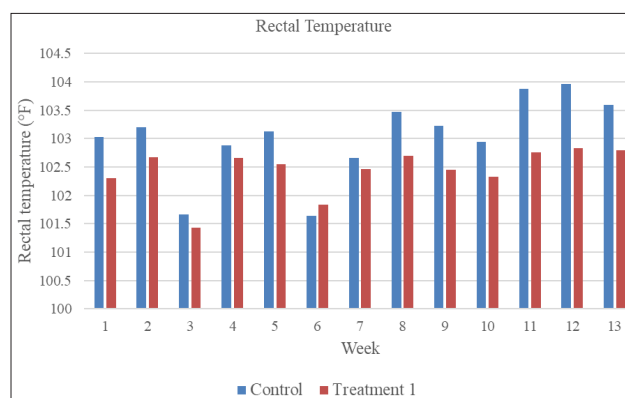


Fig. 2. Effect of microclimate modification on average rectal temperature in Nellore brown sheep

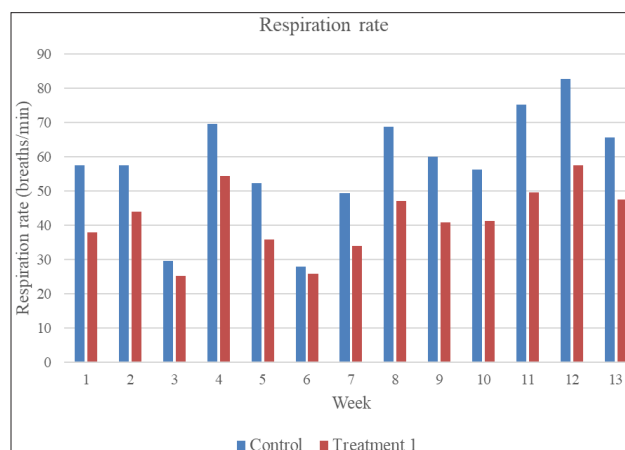


Fig. 3. Effect of microclimate modification on average respiration rate in Nellore brown sheep

groups were highly significant ($p < 0.01$). The sheep in control group had comparatively higher respiration rate to facilitate heat loss during heat stress condition. While in the treatment group the foggers and fans might have provided evaporative cooling effect inside the animal sheds. These results were in consonance with the findings of Seerapu *et al.* (2015), Ranjana *et al.* (2017) and Sinha *et al.* (2019) who reported that providing foggers and fans-controlled respiration rate to maintain normal range in buffaloes and cows. On contrary to these findings, Savaliya *et al.* (2019) reported non-significant difference in respiration rate in buffaloes by providing foggers in the sheds.

Graphical representation of average pulse rate at weekly intervals in Nellore brown sheep was presented in fig. 4. The mean evening pulse rate (beats/min) in Nellore brown sheep was 105.16 ± 0.67 and 90.53 ± 0.59 in control and treatment group, respectively. Average mean pulse rate was 95.42 ± 0.55 and 87.94 ± 0.52 in control and treatment group, respectively. The evening and day average pulse rate was significantly ($p < 0.01$) lower in treatment group as compared to control group. Pulse rate is indicative of the homeostasis of circulatory system and general metabolic status of the animal (Marai *et al.*, 2007). In the current study, the sheep in control group showed higher pulse rate due to heat stress. The rise in pulse rate could be attributed to the amplified blood flow to the body surface area, which is essential for increased heat dissipation. Sheep have the ability to constrict or dilate blood vessels in their face to regulate their heat balance. The sheep in the treatment have lower pulse rate compared to control group the probable reason might be due to evaporative cooling effect caused by the provision of foggers and fans in treatment group. These results were in agreement with those reported by Seerapu *et al.* (2015) and Sinha *et al.* (2019) who stated that foggers and fans decreased pulse rate in buffaloes and cows respectively.

In conclusion, it may be stated that microclimate modification by provision of fans and foggers in the sheds decreased the THI values which in turn reduced the heat stress on sheep and provided comfortable environment



Fig. 4. Effect of microclimate modification on average pulse rate in Nellore brown sheep

and also minimize the effect of heat stress in summer by maintaining normal physiological responses (rectal temperature, respiration rate, pulse rate) during summer season under intensive sheep production system.

REFERENCES

- Chandra B, Singh S V, Hooda O K, Upadhyay R C and Beenam V M. 2012. Influence of temperature variability on physiological, hematological and biochemical profile of growing and adult Sahiwal cattle. *Journal of Environmental Research and Development* 7 (2A): 986-94.
- Gaughan J, Lacetera N, Valtorta S E, Khalifa H H, Hahn L and Mader T. 2009. Response of domestic animals to climate challenges. *Biometeorology for adaptation to climate variability and change* 131-70.
- Gaughan J B, Bonner S, Loxton I, Mader T L, Lisle A and Lawrence R. 2010. Effect of shade on body temperature and performance of feedlot steers. *Journal of Animal Science* 88: 4056-67.
- Goswami S. 2021. Implementation of automatic cooling system for cattle shed and its effect on milk production. *Indian Research Journal of Extension Education*.
- Khongdee S. 2008. The effects of high temperature and housing modification on the productive and reproductive performance of dairy cows. Thesis submitted to graduate school, Kasetsart university.
- LPHSI L. 1990. Poultry heat stress indices agriculture engineering technology guide. Clemson university. 29634 (4).
- Marai I F M, El-Darawany A A, Fadiel A and Abdel-Hafez M A M. 2007. Physiological traits as affected by heat stress in sheep-a review. *Small Ruminant Research* 71(1-3): 1-12.
- Ranjana S, Kamboj M L, Ashish R and Lathwal S S. 2017. Effect of modified housing on behavioural and physiological responses of crossbred cows in hot humid climate. *Indian Journal of Animal Sciences* 87(10): 1255-8.
- Savaliya B D, Parikh S S, Makwana R B, Patbandha T K, Gamit P M and Murthy K S. 2019. Effect of microclimate alteration on temperature humidity index (THI), milk production and milk composition in Jaffrabadi buffaloes during summer. *International Journal of Current Microbiology and Applied Sciences* 8 (4): 1379-85.
- Seerapu S R, Kancharana A R, Chappidi V S and Bandi E R. 2015. Effect of microclimate alteration on milk production and composition in Murrah buffaloes. *Veterinary world* 8(12): 1444.
- Sejian V, Bhatta R, Gaughan J, Malik P K, Naqvi S M K and Lal R. 2017. Adapting sheep production to climate change. *Sheep Production Adapting to Climate Change* 1-29.
- Silanikove N, Maltz E, Halevi A and Shinder D. 1997. Metabolism of water, sodium, potassium and chloride by high yielding dairy cows at the onset of lactation. *Journal of Dairy Science* 80 (5): 949-56.
- Sinha R, Kamboj M L, Lathwal S S and Ranjan A. 2018. Effect of housing management on production performance of crossbred cows during hot-humid season. *Indian Journal of Animal Research* 52(7): 1091-4.
- Sinha R, Kamboj M L, Ranjan A and Devi I. 2019. Effect of microclimatic variables on physiological and hematological parameters of crossbred cows in summer season. *Indian Journal of Animal Research* 53(2): 173-7.
- Verma K K, Singh M, Gaur G K, Patel B H M, Verma M R, Maurya V P and Singh G. 2015. Effect of different heat ameliorating measures on micro-climatic variables in loose

- houses during hot humid season in Murrah buffalo heifers. *Journal of Animal Research* **5**: 779-83.
- West J W, Hill G M, Fernandez J M, Mandebvu P and Mullinix B G. 1999. Effects of dietary fiber on intake, milk yield and digestion by lactating dairy cows during cool or hot, humid weather. *Journal of Dairy Sciences* **82**: 2455-65.