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Assessing the Temperature Conditions and Behavioral Habits in a Farm to Ensure Cattle Welfare

Dr. Sachin Gupta[1]*, Baldev Singh[2], A Rengarajan[3]

[1]Chancellor, Department of Management, Sanskriti University, Mathura, Uttar Pradesh, India, Email Id- chancellor@sanskriti.edu.in, Orcid Id- 0000-0002-4900-0082

[2]Professor, Department of Computer Science & Engineering, Vivekananda Global University, Jaipur, India, Email Id- baldev_singh@vgu.ac.in, Orcid Id- 0000-0002-4729-5358

[3]Professor, Department of Computer Sceince and Information Technology, Jain (Deemed to be University), Bangalore, India, Email Id- a.rengarajan@jainuniversity.ac.in, Orcid Id- 0000-0002-4168-3333

Abstract

In contemporary agriculture, it is imperative to comprehend the environmental factors and behavioral patterns of cattle, as their productivity and well-being are impacted by temperature fluctuations. The compost barn system has become increasingly popular due to its capacity to improve animal welfare and quality of life. To evaluate animal comfort and perhaps improve management, the use of compost barns in dairy farms demands extensive research on thermal conditions and behavior. In addition to evaluating the cows' standing and laying habits through photographs, this investigation attempted to define the temperature environment in a microbial farm during each of the four seasons. In Raipur, the Indian capital of Chhattisgarh, a compost barn utilized the experiment's location. The inclusion requirements for ensuring cow well-being on farms include things like proper ventilation, sufficient shelter that access to a clean and consistent water supply, which are used to evaluate the general temperature along with cow behavior in an ideal range. The temperature and humidity index (HI) was computed after daily data from different seasons were gathered for the year-round experiment. The interior of the cows' barn was filmed and the footage was visually and automatically processed to evaluate the behavior of the cattle. The study correctly recognized cow behavior over the study period, indicating that the largest mean levels of HI occurred in the afternoon and fall, matching with the animals' apparent inclination to spend the majority of the day lying down on the bed. The study focuses on the complex relationship between temperature and cattle behavior, providing useful insights into the elements influencing their well-being.

Keywords: Cattle Behavior, Temperature Conditions, Compost Farms, Humidity Index

INTRODUCTION

High temperatures, low air humidity as well as low rainfall make dairy cattle breeding in semi-arid regions difficult, affecting animal health and production. Environmental adaptability determines dairy cattle health (1). Environmental challenges adapt harder, requiring more effort from animals and lowering their well-being. Modern housing techniques like compost barns are used to improve animal comfort (2). A unique composting process optimizes comfort, extends cow longevity, reduces initial facility costs, lowers mastitis risks and improves milk quality. Assessment of composting efficiency requires bed surface temperature monitoring in compost barns (3). Infrared thermometers measure compost bedded pack barn surface temperatures. Carbon barn confinement systems for dairy cattle are becoming more and more popular among milk producers as a substitute technique to improve milk quality and production (4). Both better financial returns and more animal comfort are the goals of this strategy. A large bed area and a feed lane, which is divided from the bed by a wall or opening, make up the structure of a compost barn (5). The bedding, which is typically a layer of wood shavings 20 to 25 cm high, absorbs moisture from waste that is breaking down (6). In addition to provide a well-balanced feed, keeping appropriate thermal conditions

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in the range of ambient temperatures is essential for optimizing the genetic potential of animals (7). As a result, the animals can better utilize the energy from their meal, require fewer physiological modifications, maintain a normal body temperature and exhibit regular appetites since they are not disturbed by excessive heat or cold (8). Uncomfortable animals can make behavioral, metabolic and physiological adjustments that result in higher energy costs and lower potential for productivity. Strict systems, such as compost barns, provide an alternative to traditional milk production methods (9). The health of the animals can suffer from a lack of understanding of facility management and animal care. It can lead to difficulties like reduced intake of dry matter, udder health issues, infertility and a direct effect on productivity if the environmental requirements of animals are not met (10). Different techniques use direct and indirect markers to classify animal welfare in husbandry systems. Similar to environmental characteristics, indirect indicators provide quick and accurate insights into management and production systems. The animal's physiology, temperament and overall health are its primary indicators. The goal of this research is to determine methods to monitor bed surface temperature in Thermal Stress Biomarkers (TSB) that comprehend the influence of weather on metrics related to health and well-being in fertilizer farm systems to milk cows.

The study (11) addressed that the main goal is tracking TSB in dry and wet conditions seasons while assessing the physiological, behavioral and environmental characteristics of dairy cattle. The article (12) used to geostatistics to make relationships between these variables and the animals' thermal comfort. The research (13) evaluated the findings showed that weather wasn't as favorable during the dry spell, which caused the animals' respiratory frequency (RF) to be higher ($P < 0.05$) and their TSB to be elevated. The study (14) explored the rainy period; the dry period's environmental conditions caused discomfort in the animals, which raised their need for thermoregulation. The article (15) introduced that cattle raised in the Worm Farm System of Brazil experienced behavioral changes as a result of this. The research (16) used geo-statistical techniques to monitor the bed temperature and the animals' physiological and behavioral parameters with the temperature environment of compost barn systems and develop relationships. The study (17) used to compost barns has grown in favor as a means of improving animal welfare and quality of life, which in turn has increased longevity and output. Compost barns are used on dairy farms; therefore, it is critical to study animal behavior and the thermal environment to evaluate welfare and make appropriate adjustments to management procedures. The article (18) used imaging to assess the sitting and walking behaviors of cows as well as the thermal conditions in a compost barn throughout four seasons. The experiment took place in November (winter), October (fall), September (summer) and December (spring). The research (19) provided that every ten minutes, measurements were taken of the relative humidity (RH %). It was calculated to get the “Temperature and Humidity Index (THI)”. The study (20) investigated the cow behavior was assessed using automatic and visual analysis of barn interior film, enabled quick as well as automated evaluation, along with correctly identified cow activity.

MATERIALS AND METHODS

This study examines temperature differences across ten places while examining street cattle in Raipur, Chhattisgarh, India. Utilizing a monitoring system for visual and algorithmic analysis, behavioral observations are concentrated on compost barns. The effects of the climate on physiological markers are shown by statistical analyses, which highlight the importance of heat stress during high temperatures. The impact of bedding temperature on resting behavior highlights how environmental factors are crucial for enhancing animal welfare and guiding management practices.

Dataset

In 10 different places, with ambient temperatures ranging from 21.75°C in the winter to 34.87°C in the summer, Raipur, the capital of Chhattisgarh in the Indian Federal Union, was examined. Raipur is located 298 meters above

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sea level and has an area of 226 km². The investigated areas, which included Gol Chowk and Mangal Bazar among others (21), were chosen at random according to the prevalence of animals in the area and they were distinguished by open dumping grounds. The subjects were street cattle because there could be differences in the site, time, month and season; the sample size was not indicated. The study evaluated the frequency of cattle at various sites with a focus on behavioral tendencies.

Inclusion and Exclusion Criteria

When evaluating the general temperature and cow behavior in an ideal range, good ventilation, adequate shelter and access to a clean and steady water supply are important considerations for bovine welfare on farms. Additional inclusions include healthy and well-balanced food, routine health check-ups, roomy living quarters and kind handling strategies. Preventing overcrowding, and not having enough shelter, ventilation, water supply, or nourishment are among the exclusion criteria. It is best to avoid using practices that put cattle through stress and discomfort, or jeopardize their health as well as welfare. Farmers can ensure a higher quality of overall welfare for their cattle by following these guidelines and fostering an environment that optimizes the physical health coupled with behavioral well-being of their animals.

Assessment of Animal Behavior Using Visuals

For the compost barn setup, we incorporated a surveillance system featuring the Camera Intelbras. This camera was positioned near the barn roof shears using two screws, providing an optimal vantage point. The camera was utilized to capture images for assessing the animals' behavior throughout the evaluation period. By securing it in this manner, the camera covered the entire bed area and feeding aisle, allowing for comprehensive monitoring of the animals' activities in the barn. This setup ensured a clear and encompassing view, facilitating the evaluation of behavioral patterns as well as activities crucial for understanding and promoting the well-being of the animals in the compost barn.

Four trips were made to collect movies throughout the data-collecting phase. Two different approaches were used for the analysis that followed: visual inspection and an algorithm created especially for this need. As shown in Table 1, the assessments using both methods were carried out on the same dates and times. The behavioral study was focused on determining if the animals were standing or lying down. Combining automated insights produced by the developed algorithm with visual observations, this dual-method analysis provided a thorough knowledge of the postural behavior of the animals. The dates and timings of the two investigations coincide, ensuring precision and coherence in the assessment of the animals' whereabouts throughout the research.

Table (1). Date and time of filming for automated and visually represented behavior analysis

(Source: Author)

Summer		**Autumn**		**Winder**		**Spring**	
Every Day	**period**	**Every Day**	**period**	**Every Day**	**period**	**Every Day**	**period**
05/09/2023	18:12	10/10/2023	14:47	15/11/2023	08:19	01/12/2023	13:47
05/09/2023	16:32	10/10/2023	13:47	15/11/2023	10:01	01/12/2023	15:55
05/09/2023	14:53	10/10/2023	09:17	15/11/2023	16:00	01/12/2023	17:53

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05/09/2023	10:02	10/10/2023	06:00	15/11/2023	12:05	01/12/2023	08:15
05/09/2023	07:17	10/10/2023	07:19	15/11/2023	05:56	01/12/2023	05:54

Visual Behavior Analysis

After watching recorded films at certain intervals, as indicated in Table (1), the process of visually counting animals that were lying and standing was carried out. By watching the animals in the paused movie at the halfway point, the visual count for each behavior was calculated. Spreadsheets were used to record and organize the pertinent data from these observations for later examination. The gathered photos were examined in the light of day to ensure that there was enough visibility to determine the whereabouts of the animals inside the barn. The observer's ability to visually evaluate the photographs was hampered by interference introduced during nighttime. The time of the video analysis was influenced by the sun's fluctuating declination over the seasons, which produced varied daily sun exposure. As such, there were minor modifications made to the evaluation time of the videos to align with the seasonal shifts.

Designing experiments and performing statistical analysis

Utilizing the MIXED, an analysis of variance was carried out using the data from both physiological variables and environmental monitoring, after a normality test. Day effects were handled as random variables in the study, while the inclusion of the constant impacts of changes duration and their interplay. Use Pearson's coefficient to analyze the relationships between physiological data and environmental factors. Bed TSB data using semivariogram models to interpolate data and evaluate geographical dependence. After making modifications to the semivariogram, the bed surface temperature variable in the geostatistical. This method estimated the structure and spatial dependence between observations for the variables under study as shown in Equation (1).

$$\bar{z}(g) = \frac{1}{2m_{(l)}} \sum_{j=1}^{M(l)} [Z(t_j) - Y(T_j + g)]^2 \quad (1)$$

The parameter ' g ' represents the inter-measurement spacing in the specified context. "N (K)" Is the number of experimental pairings Z (T_j) and Z $(T_j + g)$ of measured data. The unestimated (true) value of the variable at position $'xi,'$ denoted above as Z (T_j), is considered a random variable and it is dependent on the sample point '$x.'$ Z $(T_j + g)$ is equivalent to the value of the variable in any direction at point '$T_j + g$ '.

RESULT

The seasonal temperature and relative humidity fluctuations are significant, as shown by the mean values for environmental variables in Table (2) and Table (3). Relative humidity (RH) dropped over both annual periods, whereas afternoon temperatures increased significantly ($p < 0.05$). This is consistent with the solar radiation's natural increase, which peaks around 14 hours because of the sun's perpendicular position. The values were higher during the dry period ($p < 0.05$) than the acceptable temperature range of 13 to 18ºC for nursing cows.

Lower relative humidity during the hottest parts of the day could be caused by warmer air and lower relative humidity during the dry spell is associated with less rainfall. It's important to remember that low relative humidity speeds up evaporative processes, irritates skin and dehydrates animals, all of which add to discomfort. Strong sun radiation, in semi-arid intertropical zones, is the cause of daytime temperature increase. As a result of frequent temperatures above recommended levels, dairy cows in Brazil suffer from thermal stress.

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Table (2). Climate factors that affect compost barn movements

(Source: Author)

Period	Temperature $\cdot_C$	
	Morning	**Afternoon**
Dry	28.8	34.0
Rainy	27.7	32.2
Autumn	26.6	30.1
Spring	25.5	29.0

Table (3). Compost barn motions are impacted by climate considerations

(Source: Author**)**

Period	Humidity %	
	Morning	**Afternoon**
Dry	52	22
Rainy	66	33
Autumn	72	44
Spring	43	55

In comparison to the morning shift, the study found a substantial ($P < 0.05$) increase in the animals' ambient weather and Respiratory Rates (RR) during the afternoon shift is shown in Table (4) and Table (5). Research revealed that while there was a stronger correlation between higher air temperatures and relative humidity, animals housed during the rainy season appeared to be less uncomfortable in terms of heat. Because the air's relative humidity stayed below 40% throughout this time, it is noteworthy that RR during the afternoon shift exceeded 80 breaths per minute, indicating significant heat stress and associated dangers for respiratory disorders. This indicates that during periods of high temperatures and little humidity, animals have an increased difficulty sustaining respiratory health.

Table (4). Changes in dairy cattle's physiological parameters

(Source: Author)

Period	Respiratory rate (brath/min)	
	Morning	**Afternoon**
Dry	64	80
Rainy	46	69
Autumn	35	71

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Spring	22	50

Table (5). Variations in the physiological characteristics of dairy cows

(Source: Author)

Period	**Surface temperature ·$_C$**	
	Morning	**Afternoon**
Dry	33.6	36.1
Rainy	33.0	35.5
Autumn	33.2	34.4
Spring	33.7	33.2

In terms of behavioral observations, the semi-arid climate in the study region was the reason why the animals felt more discomfort during the dry period (DP). With a higher proportion of cows expressing a preference for resting in quadrants 1 and 2 during both shifts, this discomfort was reflected in behavioral changes. Reductions in feeding activity were noted in these quadrants, which benefited from artificial ventilation and warmer bed temperatures. This was evident in high temperatures, as indicated by the higher RR found during this time. When compared to the dry season, cows prioritized longer eating periods during the rainy season, especially during the morning shift. They gave the afternoon shift more rest time and distributed their activity more evenly throughout the quadrants.

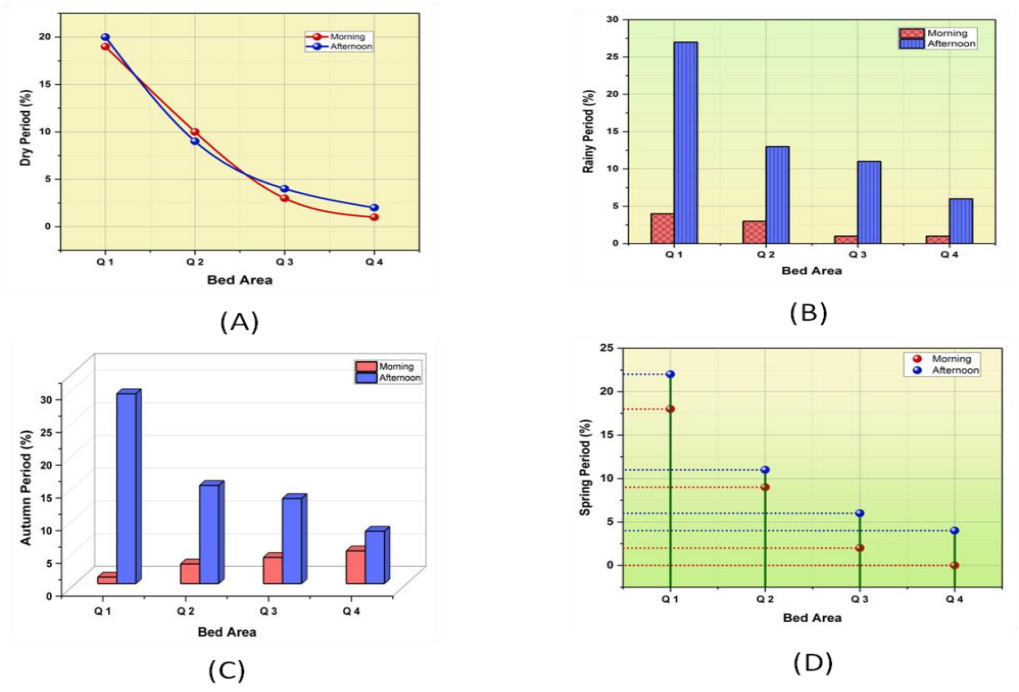

Figure (1). Quadrants of the compost barn's resting behavior as a percentage of totals (A) Dry period (B) Rainy period (C) Autumn period (D) Spring period, (Source: Author)

Figure 1 provides a visual representation of these behavioral patterns. Its assessment graphs demonstrate that fewer cows lie down in the quadrants with warmer bedding. Previous studies on the composition of bedding, such as those with a significant link between straw and organic compost between differences in the ambient temperature as well as variations in the bed surface temperature. Studies have demonstrated how bedding materials, including straw, influence confinement-based dairy cows' preferences and result in prolonged laying periods. This variation is explained by the fact that cows in the compost barn system have less competition for space, which gives them greater latitude in their movements and resting postures. Understanding these subtle behavioral patterns is essential to making sure that management approaches support the comfort and well-being of the cows by recognizing their function as biosensors responding to changes in their surroundings.

CONCLUSION

This study evaluated street cattle in 10 different places in Raipur, Chhattisgarh, India and found significant differences in temperature in the semi-arid area. Through the use of visual and algorithmic techniques, the behavior of animals in a compost barn was examined to reveal preferences about bedding temperature. Significant relationships between physiological indicators, environmental parameters and bedding temperature were revealed by the thorough statistical analysis, clarifying the effects of climate conditions on dairy cattle. The noted rise in respiratory rates during hot and muggy spells highlighted the possibility of heat exhaustion. Warmer surfaces have an impact on resting behavior; therefore the study's findings highlighted the significance of bedding composition. Compacted barns with longer laying times seem to have different preferences, which highlights the importance of the surroundings in fostering animal welfare. By guiding management approaches that promote the best possible comfort and health, these insights advance understanding of animal welfare.

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