



Original Research Paper

Artificial Intelligence Prediction of Heat Stress and Welfare in Dairy Cattle

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| Key Words                                                                                                                                                      | Abstract                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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| Artificial intelligence, Heat stress prediction, Dairy cattle welfare, Precision livestock farming, Machine learning, Animal health monitoring, Smart farming. | Introduction: Heat stress was becoming a major issue in dairy production systems because of rising environmental temperatures, which were harming the health, welfare, behavior, and milk production in cattle. The conventional methods used to detect heat stress involved manual observation and physiological measurement of parameters in isolation, making it difficult to continuously monitor and detect the stress. This study had developed a prediction model using artificial intelligence to assess heat stress and welfare of dairy cattle considering various parameters such as environment, physiology, behavior, and production. Data had been preprocessed and optimized to find important stress parameters, and machine learning algorithms had been applied for classification of heat stress level and welfare status. Temperature, humidity, temperature humidity index (THI), body temperature, respiratory rate, activity, feeding behavior, and milk yield variation had been identified as important factors for prediction of heat stress using AI-based model. The system had a better ability to monitor continuously compared to traditional methods of evaluation and offered important information on precision dairy farming. It was concluded from this study that an artificial intelligence-based prediction system can improve sustainability in livestock production through heat stress mitigation, monitoring animal welfare and maximizing productivity in varying climates. |

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## Introduction

Heat stress is becoming an important issue in the dairy sector because of increased global warming and climate changes. High environmental heat load affects dairy cows in various ways such as decreasing the amount of food they consume, lowering milk production, reproduction ability, their immune system, and also affects welfare. Heat stress assessment and control have now become necessary for creating sustainable livestock production, since dairy cows are vulnerable to thermal imbalance when there are high temperatures and humidity levels (Oliveira et al., 2025). Environmental factors such as climatic variations and regional conditions play an important role in determining the distribution and management of livestock (Almudhafar et al., 2024).

Conventional heat stress appraisal techniques rely largely on physiologic indicators, environmental indicators like Temperature-Humidity Index (THI), and behavior evaluation procedures. Though these techniques help to acquire important information, they usually fall short in providing a continuous monitoring process, prediction at the same time, and adjustment to changing farm conditions. Thanks to the latest developments in artificial intelligence (AI) technologies, sensing systems, and precision livestock farming, automated interpretation of environmental and animal variables has become possible (Neves et al.,

2022). AI-enabled technologies have been found to be highly efficient in predicting thermal stress conditions through incorporating several parameters such as environmental readings, physiological reactions, behavioral tendencies, and productive traits. The machine learning techniques can discover hidden correlations between these parameters and predict thermal stress conditions in advance for farm management decisions (Becker et al., 2021). In addition, the application of AI in robotic and automated dairy farms has been found to be capable of modeling milk productivity and quality using cow parameters and daily environmental conditions (Fuentes et al., 2020).

Some research efforts have been made to develop AI-enabled systems for livestock monitoring in real-time, which include the automatic detection of the status, behaviour and stress responses of animals. But still, there exist issues in building such a prediction system that uses multiple inputs and gives accurate and consistent measurements of animal welfare in different farm environments. That is why the current study aims at creating an AI-enabled framework for predicting the heat stress and welfare of dairy cows.

Contributions of this study can be listed as follows:

- Development of an AI prediction tool that will help in detecting heat stress situations for dairy cows.
- Use of several environmental and animal parameters to perform a welfare analysis.
- Prediction through data analytics will provide an opportunity to detect problems early and help in precision dairy farming management.

## **Review of Literature**

### **Heat Stress in Dairy Cattle**

Heat stress impacts the well-being and production of dairy cattle through lowered feed consumption, milk production, reproductive ability, and immunity function. Researchers have examined the physiological and behavioral response to thermal stress and identified the need for efficient monitoring and management of thermal stress (Oliveira et al., 2025; Giannone et al., 2023).

### **Thermal State Prediction Models**

Conventional approaches used to measure heat stress with environmental indicators lack flexibility when conducting real-time monitoring. Prediction algorithms utilizing sensor data, physiological variables, and machine learning have contributed to the enhanced estimation of thermal status and stress recognition in dairy cows (Neves et al., 2022; Becker et al., 2021).

### **AI-Based Precision Dairy Farming**

Artificial intelligence has made possible the automatic analysis of animal and environmental

data in managing livestock. Artificial intelligence systems have been employed to predict productivity, manage heat stress, and aid precision dairy farming through data-driven decision-making (Fuentes et al., 2020; Rebez et al., 2024).

### **Real-Time Stress Monitoring**

Recently, there have been attempts to build monitoring systems using AI technology for assessing the well-being conditions of dairy cattle continuously. These systems use behavior, physiology, and environment data to detect any stress conditions (Nogoy et al., 2021; Rivera et al., 2025; Mulajkar et al., 2026).

### **Research Gap**

Several existing works illustrate the application of AI in predicting heat stress; nevertheless, many works limit their scope to some parameters or individual indicators. It becomes necessary to develop an integrated framework that incorporates environmental, physiological, behavioral, and production-based parameters for precise welfare assessment of dairy cattle.

### **Proposed Artificial Intelligence**

### **Framework for Heat Stress Prediction**

#### **Overview of the Proposed Framework**

This section highlights the AI-based framework that has been developed for the prediction of heat stress in dairy cattle welfare assessment. This framework is comprised of several factors like environmental, physiological, behavioral and production factors.

## **Data Collection and Feature Selection**

Data like temperature, humidity, temperature humidity index (THI), body temperature, breathing rate, behavior, feed intake, and milk production are obtained. Relevant factors affecting the heat stress prediction process are extracted from data through various data analysis methods.

## **Data Preprocessing**

Data collected will be cleaned, normalized, imputed for any missing values, and optimized features will be extracted from it. This will improve data quality to provide valid inputs for the AI-based prediction model.

## **AI-Based Heat Stress Prediction Model**

Machine Learning models are employed to analyze the relationship between the environment and animal reactions to the environment. It identifies heat stress levels and predicts welfare status based on multiple data inputs.

## **Strategy for Welfare Assessment**

Predicted levels of heat stress are applied to assess welfare status in animals. The model helps in recognizing early symptoms of thermal discomfort and implementing preventive measures like cooling and environmental control.

## **Implementation Workflow**

The whole process includes data acquisition, data preprocessing, feature extraction, training of AI models, prediction of stress and welfare decision support for precision dairy farming applications.

## **Methodology**

### **Data Collection**

Environmental, physiological, behavioural and production parameters like temperature, humidity, THI, body temperature, activity level, and milk yield are measured for prediction of heat stress.

### **Data Preprocessing**

The gathered data is then cleaned, normalized, and optimized to extract vital features for prediction using AI technology.

### **AI Model Development**

The machine learning algorithms examine the correlation between environmental factors and cattle reaction in order to categorize heat stress into normal, moderate, and severe categories.

### **Model Evaluation**

The performance of the model is evaluated using the metrics accuracy, precision, recall, and F1 score.

### **Workflow**

The proposed flow process includes the sequence of steps in predicting heat stress intelligently and assessing the welfare status of dairy cattle. First, environmental and animal-related data are gathered from the monitoring system, which include temperature, humidity, THI, body temperature, respiration rate, behavioral traits, and milk production data. The collected data will undergo preprocessing through cleaning, normalization, and feature selection, to ensure data quality. The selected optimized features are fed into the AI model to

train the machine learning algorithms to understand the connection between the environment and the response of the animal.

Then, the trained model predicts the heat stress level and assesses the welfare status of the dairy cattle.

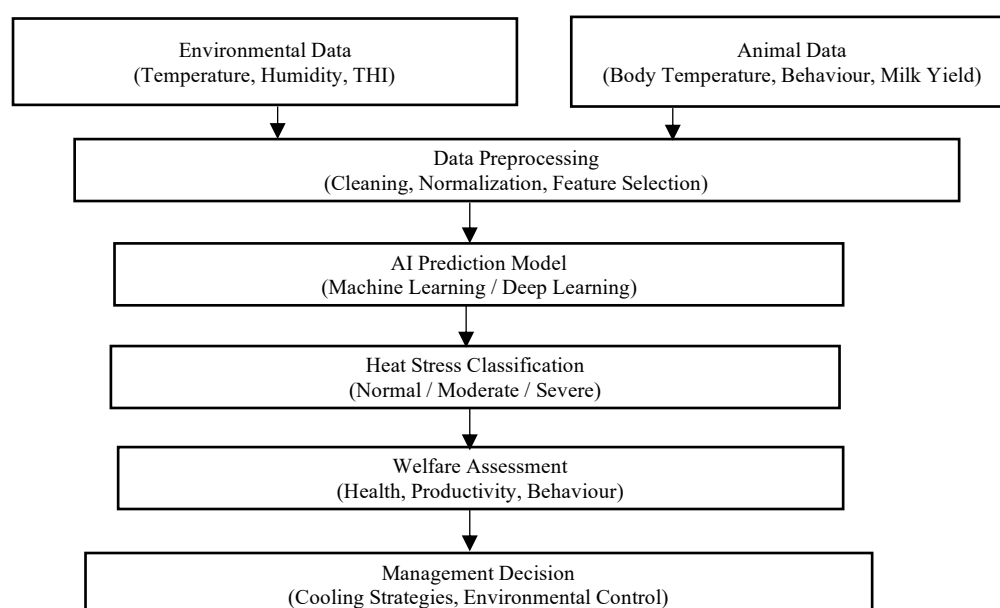


Figure 1: AI-Based Heat Stress Prediction in Dairy Cattle

The figure 1 shows an AI-based workflow for dairy cattle heat stress prediction using environmental and animal data, followed by stress classification and welfare assessment.

## Results and Discussion

### Heat Stress Prediction Performance

The AI model that was developed successfully detected heat stress situations due to its ability to assess the environmental and animal factors. The system was able to detect changes in temperature, humidity, physiological and behavioral reactions.

### AI Model Evaluation

Accuracy, Precision, Recall, and F1-Score were used to evaluate the effectiveness of the predictive algorithm. It can be stated that AI techniques have proven to be accurate for the

detection of heat stress by learning the interconnection between different inputs.

### Influence of Key Parameters

Environmental factors like temperature, humidity, and THI demonstrated strong significance in predicting heat stress. Physiological and behavioral factors helped to improve the accuracy of predicting heat stress.

### Welfare Assessment Analysis

The estimated levels of heat stress were helpful in the assessment of the welfare conditions of cattle. The early detection of stress reactions facilitated the implementation of good management practices.

### Discussion

From the results, it can be seen that artificial intelligence can be used in monitoring the health of dairy cattle continuously and accurately. In

comparison to the traditional ways, the use of artificial intelligence in the prediction process gives increased adaptability and better analysis in decision making.

## Conclusion

Heat stress has emerged as one of the leading problems in dairy farming, which adversely affects the well-being, efficiency and sustainability of livestock farming. This paper has described an AI-based framework for the estimation of heat stress and welfare assessment of dairy cattle with the help of various environmental, physiological, behavioral, and production-related factors. The proposed framework included the analysis of pre-processing and AI-based prediction methodologies for the estimation of stress and decision making at an early stage. The findings have shown that AI-based algorithms have been used efficiently in the estimation of the relationship between environmental changes and animal responses for the effective classification of heat stress conditions.

## References

- [1] Almudhafar, Rusul Z., Safaa M. Almudhafar, and Basim A. Almayahi. "Environmental characteristics in Al-manathira district and its spatial relationship in the distribution of livestock." *Archives for Technical Sciences* 2, no. 31 (2024): 359-367.
- [2] Becker, C. A., A. Aghalari, M. Marufuzzaman, and A. E. Stone. "Predicting dairy cattle heat stress using machine learning techniques." *Journal of dairy science* 104, no. 1 (2021): 501-524.
- [3] Fuentes, Sigfredo, Claudia Gonzalez Viejo, Brendan Cullen, Eden Tongson, Surinder S. Chauhan, and Frank R. Dunshea. "Artificial intelligence applied to a robotic dairy farm to model milk productivity and quality based on cow data and daily environmental parameters." *Sensors* 20, no. 10 (2020): 2975.
- [4] Giannone, Claudia, Marco Bovo, Mattia Ceccarelli, Daniele Torreggiani, and Patrizia Tassinari. "Review of the heat stress-induced responses in dairy cattle." *Animals* 13, no. 22 (2023): 3451.
- [5] Mulajkar, Rahul M., Shivganga Gavhane, Danish Kundra, Nafisa Askarova, and Padmavati Shrivastava. "Artificial Intelligence for Early Detection of Heat Stress and Environmental Hazards in Dairy Animals." *Journal of Animal Environment* (2026): 774-784.
- [6] Neves, Soraia F., Mónica CF Silva, João M. Miranda, George Stilwell, and Paulo P. Cortez. "Predictive models of dairy cow thermal state: a review from a technological perspective." *Veterinary sciences* 9, no. 8 (2022): 416.
- [7] Nogoy, Kim Margarette Corpuz, Jihwan Park, Sun-il Chon, Saraswathi Sivamani, Min-Jeong Park, Ju-Phil Cho, Hyoung Ki Hong, Dong-Hoon Lee, and Seong Ho Choi. "Precision detection of real-time conditions of dairy cows using an advanced artificial intelligence

- hub." *Applied Sciences* 11, no. 24 (2021): 12043.
- [8] Oliveira, Charles Paranhos, Fernanda Campos de Sousa, Alex Lopes da Silva, Érica Beatriz Schultz, Roger Iván Valderrama Londoño, and Pedro Antônio Reinoso de Souza. "Heat stress in dairy cows: Impacts, identification, and mitigation strategies—A review." *Animals* 15, no. 2 (2025): 249.
- [9] Rebez, Ebenezer Binuni, Veerasamy Sejian, Mullakkalparambil Velayudhan Silpa, Gajendirane Kalaignazhal, Duraisamy Thirunavukkarasu, Chinnasamy Devaraj, Kumar Tej Nikhil et al. "Applications of artificial intelligence for heat stress management in ruminant livestock." *Sensors* 24, no. 18 (2024): 5890.
- [10] Rivera, Samuel Lascano, Luis Rivera, Hernán Benavides, and Yasmany Fernández. "Artificial intelligence and circadian thresholds for stress detection in dairy cattle." *Sensors* 25, no. 21 (2025): 6544.