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Different indices for determining heat tolerance in farm animals.

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Introduction

Climate change poses a significant challenge to livestock systems globally. The rise in global temperatures and alterations in climate patterns, including fluctuating precipitation and more frequent extreme weather events, are impacting feed and water availability, as well as the health and productivity of animals. Livestock production is under mounting pressure due to these effects. These changes are already affecting livestock performance in various regions and are expected to have increasingly significant consequences in the future. Climate change is predominantly described as an increase in annual mean global temperatures. In the last 100 years, the mean annual temperature, for example, has risen by approximately 1 °C. Here, a further increase of 1–3 °C is predicted by the middle of the century, and a 2–4 °C increase by the end of this century. Tolerance to heat stress is worth noting considering the constant increase in the ambient temperature and high productivity that elevates the likelihood of heat stress in the animal herd. Besides exposure to hot temperatures, an increase in the performance of farm animals is positively related to heat load which results in heat stress. This necessitates the need to incorporate heat tolerance in the breeding objectives. Heat stress sensitivity is influenced more by environmental factors than genetics. Heat tolerance, or resistance to heat stress, is recognized as an economically significant trait, with indicators including declines in milk, fat, and protein yield as the Temperature-Humidity Index (THI) surpasses the comfort threshold. Heat tolerance level can be further elaborated in two ways: as the extent of performance decrease when exceeding the comfort threshold, and by identifying the THI value at which performance decline begins in dairy cattle.

Heat tolerance indices

Heat tolerance in animals is an adaptive mechanism that allows them to endure elevated ambient temperatures beyond the thermal neutral zone's (TNZ) limit, as defined by the Temperature-Humidity Index (THI). Various criteria have been proposed to identify heat tolerance in animals, encompassing parameters such as body temperature, respiration rate, heart rate, and sweating rate. Additionally, measures like hair and coat characteristics, including shedding rate and body surface-to-mass ratio, are linked to the animal's ability to dissipate internal heat. Several biomarkers, including blood parameters and different molecules associated with the heat stress response, have been suggested to measure heat stress in livestock. While physiological characteristics like body temperature or respiration rate are crucial measures for heat tolerance, their implementation in large-scale selection programs is constrained by cost. In contrast, biomarkers for heat stress present in milk spectra offer a potentially inexpensive means to identify heat-tolerant animals. A heat-tolerant animal is capable of maintaining homeostasis amidst high environmental heat loads. However, from a livestock breeding perspective, the focus may shift towards sustaining productivity and reproductive levels during heat stress. This hinges on the animal's capacity to balance thermogenesis and heat dissipation. Furthermore, mid-infrared spectroscopy has emerged as a tool to assess milk fatty acid profiles, potentially serving as biomarkers for heat stress in dairy cattle. It has been suggested employing thermographic images to measure a cow's body temperature. Conversely, the use of intraruminal sensors as a more effective alternative for this purpose. These sensors are positioned in the reticulum to enable continuous temperature monitoring.

Temperature–Humidity index (THI)

The Temperature-Humidity Index (THI) is commonly used to assess heat stress risk, combining temperature and humidity data obtained from meteorological weather stations. Wet and dry bulb thermometers are utilized to calculate THI, providing an estimate of heat stress (Dikmen and Hansen, 2009). Additionally, the wet bulb thermometer offers an indirect method for measuring humidity. Regression analysis of THI against performance data like milk yield helps determine tolerance to heat stress. Several studies have shown a negative correlation between THI and performance metrics. Heat stress in dairy cows typically begins when THI exceeds 72, although critical temperatures may vary among individual cows due to factors such as acclimation (Dikmen and Hansen, 2009).In regions with dry climates, tolerance to heat stress is primarily limited by dry bulb temperature, while in humid areas, relative humidity also plays a significant role. Combining THI with daily performance records can aid in estimating the genetic component of heat stress tolerance (Mader *et al*., 2006). Modeling performance against continuous THI values can help identify productive dairy cows less sensitive to temperature increases.

Iberia Heat Tolerance Index (IHTI)

One of the earliest indices developed to assess thermal stress in animals is the Iberia Heat Tolerance Index (IHTI), introduced by Rhoad in 1944. This index utilizes rectal temperature (RT) as a key variable. The method involves conducting tests in an open area between 10 AM to 3 PM when ambient temperatures range between 85-95°F. Rectal temperature and respiration rate of animals are recorded before and after exposure for three consecutive days.

The heat tolerance coefficient (HTC) is calculated using the formula:

$$HTC = 100 - 10\,(RT - 101)$$

Where HTC represents the Heat Tolerance Coefficient, and RT denotes the Rectal Temperature.

An HTC value exceeding 100 indicates a heat-tolerant animal. In cases where two animals possess the same HTC value, the animal with the lower respiration rate (RR) is considered more heat-tolerant.

Gaalaa's Heat Tolerance Index (HT)

The Gaalaa's Heat Tolerance Index (HT) introduced by R.F. Gaalaas in 1947 is derived from Rhoad's equation (IBHC) and is conducted under similar conditions. It is calculated using the formula $HT = 100-14(RT-101)$, where HT represents Heat Tolerance and RT denotes Rectal Temperature. A HT value exceeding 100 indicates a heat-tolerant animal. In cases where two animals have the same HT value, the one with the lower Respiration Rate (RR) is considered more heat-tolerant.

Benezra's Coefficient of Adaptability (BCA)

Benezra's Coefficient of Adaptability (BCA), devised by M.V. Benezra in 1954, utilizes Rectal Temperature (RT) and Respiration Rate (RR) responses of animals after exposing them for 7 hours over three consecutive days. The formula for BCA is $BCA = RT/38.3 + RR/23$, where normal RT is 38.33°C and normal RR is 23 breaths per minute. A BCA value of 2 signifies maximum adaptability, with values exceeding 2 indicating lower adaptability.

Dairy Search Index (DSI)

The Dairy Search Index (DSI), introduced by CK Thomas and coworkers in 1973, incorporates physiological parameters such as rectal temperature, pulse rate, and respiration rate. These parameters are recorded after exposing the animals for 7 hours on a sunny or cloudy day. The DSI is calculated using the formula

$$DSI = 0.5(X1/X) + 0.3(Y1/Y) + 0.2(Z1/Z)$$

where X1, Y1, and Z1 represent the respective parameters after exposure, and X, Y, and Z represent the same parameters before exposure. A DSI value closer to 1 indicates greater heat tolerance in the animal.

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Comprehensive Climate Index (CCI)

The Comprehensive Climate Index (CCI), also known as the Cattle Comfort Index or Climate Comfort Index, was developed by animal scientists at the University of Nebraska and the University of Queensland in Gatton, Australia, to evaluate environmental stress. CCI considers multiple weather variables, including ambient temperature, relative humidity, wind speed, and solar radiation. CCI emerges as a promising thermal index for evaluating heat stress in dairy cows housed indoors. Unlike previous stress models, CCI offers several advantages, It combines assessments of both heat and cold stress within a single model (Yan *et al*., 2021). The model remains applicable throughout all seasons, year-round. Solar radiation is factored in as a heat enhancer and cold mitigator. Relative humidity is included as an additional variable for cold weather. The wind is incorporated as a mitigating factor for heat stress.

Index of thermal stress for cows (ITSC)

A new thermal stress index for dairy cows in inter-tropical regions, particularly semi-arid areas, was developed (Silva *et al.*, 2015). Holstein cows were assessed for rectal temperature, respiratory rate, and rates of heat exchange by convection, radiation, skin surface evaporation, and respiratory evaporation. Environmental factors such as air temperature, wind speed, relative humidity, effective radiant heat load, and short-wave solar radiation were also measured. Atmospheric transmittance (τ) values specific to tropical regions were determined to enable accurate estimates of solar radiation. Principal component analysis was used to condense the measurements into a single synthetic variable, which was then used to derive several indexes through multiple regression analysis of environmental variables using software.

Equivalent temperature index (ETIC)

A new thermal index model, known as ETIC, was created to estimate the level of heat stress experienced by dairy cattle (Wang *et al*., 2018). ETIC takes into account air temperature, relative humidity, air velocity, and solar radiation, adjusting their effects to equivalent air temperatures. This model provides a prediction of heat stress by linearly combining these factors.

Conclusion

Heat tolerance is increasingly important in modern livestock farming due to its link to negative impacts of heat stress amid rising production. Climate change exacerbates heat stress in farm animal herds. Cows undergo physiological adjustments, like acclimation, to mitigate heat stress. Several thermal indices have been proposed for assessing the thermal status of farm animals, including the Temperature Humidity Index (THI), adjusted-THI, Comprehensive Climate Index (CCI), Index of

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Thermal Stress of Cows (ITSC), and Dairy Heat Load Index. However, existing indices suffer from various limitations such as may not incorporate all relevant environmental parameters, some were developed solely from environmental data without considering physiological responses of the animals, and/or may not accurately reflect the conditions of modern high-producing dairy cows or specify production levels. These shortcomings restrict the efficacy of these indices in accurately predicting or assessing the thermal status of farm animals thereby emphasizing the need for further standardized indices.

References

Mader, T. L., Davis, M. S., & Brown-Brandl, T. (2006). Environmental factors influencing heat stress in feedlot cattle. Journal of animal science, 84(3), 712-719.

Da Silva, R. G., Maia, A. S. C., & de Macedo Costa, L. L. (2015). Index of thermal stress for cows (ITSC) under high solar radiation in tropical environments. International Journal of Biometeorology, 59, 551-559.

Wang, X., Gao, H., Gebremedhin, K. G., Bjerg, B. S., Van Os, J., Tucker, C. B., & Zhang, G. (2018). A predictive model of equivalent temperature index for dairy cattle (ETIC). Journal of thermal biology, 76, 165-170.

Yan, G., Li, H., & Shi, Z. (2021). Evaluation of thermal indices as the indicators of heat stress in dairy cows in a temperate climate. Animals, 11(8), 2459.

Dikmen, S. E. R. D. A. L., & Hansen, P. J. (2009). Is the temperature-humidity index the best indicator of heat stress in lactating dairy cows in a subtropical environment?. Journal of dairy science, 92(1), 109-116.

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