THE SCIENCE WORLD
A Monthly e Magazine
ISSN:2583-2212
April, 2023; 3(04), 540-544

Popular Article

Precision Livestock Farming Technologies for thermal stress management in Farm animals

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https://doi.org/10.5281/zenodo.7874835

Abstract

Heat stress has become a major issue in the era of climate change. Together with climate change and the drivers of burgeoning population led developmental changes will add on to the tough set of challenges for the livestock sector. Therefore, to maintain the quantity and quality of livestock products in the advent of increase in global temperature, role of precision dairy farming tools is of paramount importance. Precision dairy farming tools are used to measure physiological, behavioural and production indicators on individual animals to improve management strategies and physical resource variability to optimize economic, social benefits and minimize environmental impact. Recently developed on-animal and off-animal automated technologies for collection of temperature, animal behaviour, respiration rate has increased the feasibility of effective monitoring of heat stress in animals.

Introduction

Livestock is an integral part of agricultural system and majority of the world's population depends on it for their livelihoods. However, the livestock production in turn is critically affected by climate related variability and extremity. In spite of large-scale development of breeds and production technologies to optimize and sustain the livestock productivity in the recent past, the latter continues to be affected significantly by number of climatic factors. Deviation from the optimal environmental conditions adversely affects the animal productivity and growth. Rising global earth surface temperature is one of the most intriguing factors emerging from the changing climate. Heat

stress is well documented as a cause of significant financial loss in cattle production throughout the world. It is likely that the financial losses will be greater if proper monitoring and mitigation strategies are not implemented in line with continued global warming and increased intensity and duration of heat waves. Cattle heat stress monitoring and mitigation decisions have been traditionally based either on visual monitoring of animal response or on weather-based indices incorporating climatic factors and animal factors. As visual monitoring is impractical for large commercial farms and weather-based indices are impacted by individuality and microclimatic variability within farm, there is a need for autonomous monitoring systems to determine the degree of heat stress on a real-time basis

Therefore, to maintain the quantity and quality of livestock products in the event of increased global temperature, the role of precision dairy farming tools is of paramount importance. Precision dairy farming tools are used to measure physiological, behavioural and production indicators on individual animals to improve management strategies to minimize environmental impact and to optimize economic and social benefits.

Empirically, precision livestock farming (PLF) may be defined as a set of farming practices, which include use of advanced technologies, to deliver better results in livestock farming. PLF encompasses collection of data from animals and their environment by innovative, simple and low-cost techniques, followed by evaluation of the data by using knowledge-based computer models. Under precision livestock farming, livestock is monitored by continuous automated real-time animal monitoring systems to improve production, health and welfare and environmental impact. Large animals are tracked "per animal", however other animals, such as poultry, are tracked "per flock".

The basic objectives of PLF are to maximize individual animal potential, early detection of diseases and increase longevity, minimizing the use of medication through preventive health measures, supplements observation activities of skilled herd persons, reduction in number of farms labour required, optimize economic, social and environmental farm performance. Helps to make timely important decisions and informed decisions, resulting in better productivity and profitability.

Precision livestock farming in heat stress detection

Thermal stress indices which indicate the magnitude of thermal stress enforced on the animal have existed for years, but remain underutilized as they lack the comprehensive integrated approach of encompassing the technological advances in livestock rearing, information communication and

the traditional rearing practices that farmers follow as a part of their farm management. Recently developed automated technologies for collection of temperature, animal behaviour, respiration rate has increased feasibility of effective monitoring of heat stress in animals.

On animal thermal stress monitoring technologies

Respiration Rate monitor

Increased respiration rate is a primary response in heat stress and it is responsible for 60 % of total body heat loss. The pressure changes associated with chest muscle movement and its tone, flank movement and amount of exhaled air form the basis of autonomous respiratory rate. Long term respiration rate can be automatically monitored through different sensors like thin-film pressure sensors, pressure sensors with data filter algorithm, differential pressure sensors and Micro-electro-mechanical-system (MEMS) based magnetic sensors.

Radio Telemetric Temperature Sensors

Biosensors have been developed to detect cattle body temperature and it accounts for individual variability in thermoregulation. Recently developed Radio Telemetric Temperature Sensors includes temperature sensing ear-tags, wearable and implantable (micro-chips) devices, rumen-reticular boluses and intra-rectal and intravaginal devices and accelerometer tags. However, temperature-logging sensors without remote transmission of data option limits real-time temperature monitoring.

Temperature sensing ear-tags

Temperature sensing ear tags has been used to measure the real-time tympanic temperature in cattle. The hourly collection of temperature under thermoneutral and heat stress conditions have enabled effective monitoring of heat stress status. However, tag placement and probe dislodgment can limit the heat stress detection accuracy.

Microchip transponders

A wide range of subcutaneous microchips are being developed for the continuous measurement of body temperature in animals. Microchip transponders are generally implanted under the skin and the temperature is recorded through handheld receiver. Microchips are commonly implanted into the intra-peritoneal or intraabdominally in sheep, retroperitoneal and tail regions in goat and legs in cattle. Limitations of microchip transponders are their invasiveness and direct effects of animal physiology status like blood flow.

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Published 28.04.2023

Rumen/reticular boluses

Rumen temperature is a reliable indicator of thermal stress which increases with increase in temperature humidity index (THI). Rumen bolus is integrated with temperature sensors and chips, which detects the real-time rumen or reticular temperature and the data is collected through wireless transmission and stored.

Rectal and vaginal temperature sensor probes

Inbuilt thermal sensors such as rectal and vaginal sensor probes enable monitoring of animal core body temperature without affecting its production. Vaginal probe has better utility because of the high association between vaginal and body core temperature. It is highly effective in measuring livestock body core temperature under grazing conditions.

Accelerometer

Accelerometer tags are lightweight and has minimal interference in animal's natural behaviour. Accelerometer sensors are generally placed under lower jaw and ear to detect the behavioural alterations. It monitors complex behaviours which are direct indicative of heat stress in animals.

Real-time location systems (RTLS)

Real-time location systems (RTLS) are animal tracking systems with a fixed receiver or reader that wirelessly reads the animal's location information from a small ID tag that is attached to it. These systems are typically used indoors or in a specific, restricted areas. The location and movement of an individual animal in the proximity of feed, water and other resources can be detected and used for developing behavioural indices. The RTLS based location data can be used to develop algorithms to predict eating, drinking, lying, and grooming behaviours. This system is effective where GPS-based positioning is interrupted. Here, the individual animals that are spending more time near water and shade can be identified and thereby determine its heat susceptibility.

Off-animal thermal stress monitoring technologies

Bioclimatic indices

Bioclimatic indices are calculated by using Temperature humidity index (THI). THI provides information on the severity of thermal stress prevailing in animals. Improved weather indices such as Heat load index (HLI) has also been effectively used in livestock. Portable weather devices along with Bluetooth connectivity provides a better prediction on animal thermal stress conditions.

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Published 28.04.2023

Depth Imaging, Video Surveillance, and Artificial Intelligence

Computer vision-based video surveillance and depth imaging could be the ultimate off-animal thermal stress monitoring device in the future. Depth imaging provides better image resolution with high accuracy under different thermal stress environmental conditions. Video surveillance monitors the animal physiological and behavioural changes during heat stress. Artificial intelligence tools such as artificial neural network, fuzzy logic and machine learning based techniques are helpful in observing animal behaviour under thermal stress environment.

Infrared thermography

Infrared thermographs capture images based on the heat emitted from the animal`s body surface which is highly correlated to THI and thus provides information about animal heat stress. Thermographic indicates the increased body temperature and changes in blood circulation under heat stress conditions.

Limitations and Future Prospectives

Automated monitoring of heat stress using advanced technologies can increase the cost of farm management especially for small holding farmers. Implantation of certain temperature sensors requires expertise. The ear tags and respiration rate sensors need to be properly installed to avoid being misplaced during the animal movement. Despite having limitations, automated real-time detection of heat stress is a cutting-edge technology in precision livestock farming under the current and future climate change scenario. Customisation as per animal microenvironment, species, herd size and local weather conditions will increase the use of automated thermal stress detection technologies.

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Published 28.04.2023