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Effects of the daily heat load duration exceeding determined heat load thresholds on activity traits of lactating dairy cows

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ABSTRACT

In recent years, the problem of the welfare and heat load of dairy cows has become increasingly important in moderate climate zones. The objective of the present study was to determine heat load thresholds of average daily temperature-humidity index (THI) that lead to changes in different activity traits of lactating high-yielding dairy cows. Furthermore, we studied how the activity of the cows to heat load was influenced by the daily heat load duration which exceeded the heat load we had determined as threshold in our experiments. The study was conducted from June 2015 to May 2017 in a naturally ventilated dairy barn in Groß Kreutz, Germany. The climate was measured at several positions inside the barn, and the average THI was calculated every 10 min. The THI was used to define the dairy cows' heat load exposure. In addition, the activity of the cows was measured by pedometers, and different activity traits were recorded in the functional groups "resting behavior" and "locomotion behavior". The heat load thresholds determined by broken-stick models were 47 THI (standing bout duration, number of steps) as well as 67 THI (total lying/standing time, number of lying/standing bouts, lying bout duration). During the experimental period, the most reliable heat load threshold of 67 THI was exceeded from May to September for up to 480 h per month. The analysis model of each activity trait included the effect of the average daily THI values below and above the determined heat load threshold and the effect of the daily heat load duration exceeding the determined heat load threshold. The total lying/standing time and the number of steps showed significant changes related to increasing daily heat load duration. The effect of the daily heat load duration additionally intensified the effect of the average daily THI.

1. Introduction

An extensive literature review carried out by Gauly et al. (2013) clearly reveals that the exposure of animals to heat load will increase in the course of the predicted climate change, even under moderate climatic conditions in Central Europe. In Europe, dairy farms typically use naturally ventilated loose housing systems because of their moderate building costs, energy savings and positive impacts on the welfare of the cows. Therefore, cows are directly exposed to outside climatic conditions, which deteriorate because of climate change. The temperature-humidity index (THI) (NRC, 1971), a combination of ambient temperature and relative humidity, is commonly used to estimate the effects of the climate conditions on the heat load of cows (Herbut and Angrecka, 2018; Nasr and El-Tarabany, 2017; Schüller and Heuwieser, 2016).

Numerous studies in different climatic zones have indicated that the activity of cows is a sensitive indicator for heat load. Scientists have used many strategies to study the influence of climate conditions on cow activity. Different methods have been used to describe the climate conditions with THI, such as average THI per hour, per day or per defined parts of the day (Cincović et al., 2011; Herbut and Angrecka, 2018; Zähner et al., 2004). Furthermore, THI thresholds or THI classes were defined to distinguish different intensities of heat load (Allen et al., 2015; De Palo et al., 2005; Endres and Barberg, 2007; Provolo and Riva, 2009). The most important THI thresholds are 68 THI (Zimbelman and Collier, 2011) and 72 THI (Armstrong, 1994). They indicate the initial decrease in milk production. Herbut and Angrecka (2018) followed another new approach, which could be scientifically valuable. They divided the obtained THI values into periods characterized by different durations of THI throughout the entire day.

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At the same time, other existing studies dealing with heat load of dairy cows have utilized many different methods to record cow behavior, such as video analysis or sensor technology (Allen et al., 2015; Herbut and Angrecka, 2018; Uzal Seyfi, 2013). Various activity traits have been analyzed, including the total lying/standing time, the number of steps, the number of lying bouts, the average length of lying bout, percentage of standing/lying cows, cow comfort index, and cow stress index (Brzozowska et al., 2014; Herbut and Angrecka, 2018; Uzal Seyfi, 2013). The lying time decreased significantly with increasing heat load, and consequently, the standing time increased (Cincović et al., 2011; Cook et al., 2007; De Palo et al., 2005; Tapkı and Şahin, 2006; Zähner et al., 2004). The number of lying bouts per day is not significantly influenced by the heat load (Brzozowska et al., 2014; Endres and Barberg, 2007; Zähner et al., 2004). The average duration of each lying bout decreased as the heat load increased (De Palo et al., 2005; Endres and Barberg, 2007). The quantitative impact on the activity change of cows in relation to daily heat load duration was not analyzed until now and is introduced in this paper.

The objective of the present study was to determine heat load thresholds of average daily THI that lead to changes in different activity traits of lactating high-yielding Holstein-Friesian cows in the moderate climatic zone. It is assumed that the thresholds leading to decline in milk production as given in the literature can be different from these of activity traits. Furthermore, we studied how the activity of the cows was influenced by the daily heat load duration exceeding the determined heat load thresholds. We hypothesized that increasing heat load duration exceeding the determined heat load thresholds result in significant activity changes of the cows in the functional groups, “resting behavior” and “locomotion behavior”, in addition to the effect of the average daily THI. The novelty of the results should help to interpret the activity of cows more precisely and develop prediction models for early detection of heat load in further studies.

2. Material and methods

2.1. Barn designs, animals

The experimental farm was located in Groß Kreutz, Germany, and was situated in the moderate climate zone between the maritime and continental climate (average annual temperature 9.9 ± 7.1 °C). The measurements were carried out in a naturally ventilated dairy barn with a loose housing system (Fig. 1). The barn was 38.88 m long and 17.65 m wide and had a north-south orientation with a deviation of 18° in the clockwise direction. The height of the fiber cement roof varied from 6.2 m at the gable peak to approximately 3.6 m at the sides. At the southern gable wall the opening size was reduced by several components (calf house, room for the automatic milking system) embedded in the main building. The northern gable wall had two large gates. The western end of the building was open up to a height of approximately 1.5 m, while the eastern end was open up to the roof. The barn was equipped with 51 lying cubicles, with a mixture of straw and lime as bedding material, and an automatic milking system (Lely Astronaut A4, Maassluis, the Netherlands). Additionally, there was a fan system for cross ventilation. Two fans were installed above the lying cubicles, and one fan was above the feeding area (Fig. 2). They were manually controlled by the herd manager. The herd consisted of 51 Holstein-Friesian cows (first to eighth lactation), which had an average daily milk yield of 40.7 ± 6.8 kg per cow. The average body weight per cow was 645 ± 28 kg.

Fig. 1. Photo of the naturally ventilated dairy barn.

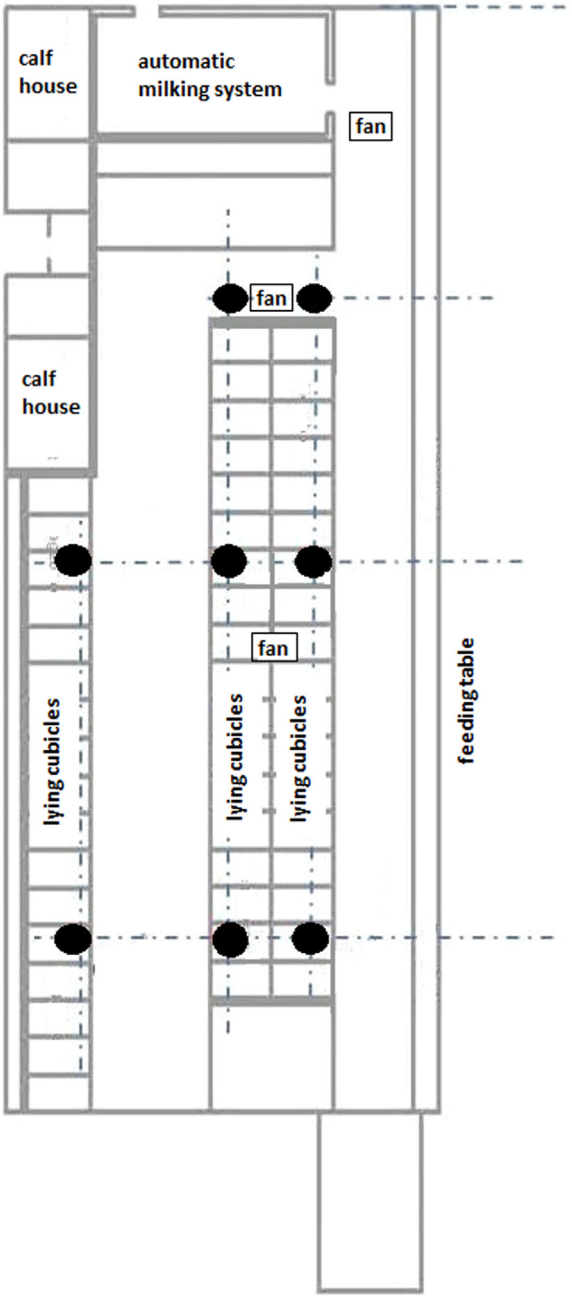

Fig. 2. Layout of the naturally ventilated dairy barn with the temperature humidity sensor positions as black points.