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Climatic effects on milk production traits and somatic cell score in lactating Holstein-Friesian cows in different housing systems

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ABSTRACT

The objective of this study was to compare the effect of the temperature-humidity index (THI) on milk production traits and somatic cell score (SCS) of dairy cows raised in 4 different housing systems: (1) warm loose housing with access to grazing (WG), (2) warm loose housing without access to grazing (WI), (3) cold loose housing with access to grazing (CG), and (4) cold loose housing without access to grazing (CI). For each of the 4 housing systems, 5 farms with a herd size of 70 to 200 lactating cows in Lower Saxony, Germany, were studied. Ambient temperature and relative humidity were recorded hourly in each barn to calculate THI. Milk production data included 21,546 test-day records for milk, fat, and protein yield, and SCS. These data were associated with the average THI of the 3 d preceding the respective measurement, which was divided into 6 classes (<45, ≥45 to <50, ≥50 to <55, ≥55 to <60, ≥60 to <65, and ≥65). Furthermore, bulk milk samples including the fat and protein percentage, and SCS taken 4 to 6 times per month were associated with the average and maximum THI of the 3 d before sampling. Data were recorded from April 2010 to March 2011. In each of the housing systems, monthly THI values above 60, indicating heat stress, were recorded between June and September, with higher values in WI and WG. In all systems, fat-corrected milk, fat, and protein yields of the test-day records decreased in tendency from 60 ≤ THI < 65 to THI >65. In WI and CI, values for SCS were greater in the class THI >65 than in 60 ≤ THI < 65, whereas no difference between any of the THI classes was found in WG and CG. The fat and protein percentage of the bulk milk samples decreased with increasing 3-d maximum THI in all 4 systems, whereas the SCS increased with increasing 3-d average THI. In conclusion, negative effects of heat stress conditions under a temperate climate on milk production traits and SCS were found, although a housing system being superior to the other systems in altering heat stress effects was not identified.

Key words: heat stress, milk production trait, somatic cell score, housing system

INTRODUCTION

Livestock production and welfare is affected by various factors due to complex interactions between the individual animal and the environment with its different factors. Especially when the scenarios of global warming are considered, heat stress of high-yielding dairy cows is an increasing concern of milk producers in Europe (Gauly et al., 2013). Compared with the reference period of 1971 to 2000, mean annual temperatures are predicted to rise by 1°C for the period of 2021 to 2050 and 2.5°C for the period of 2071 to 2100 in Lower Saxony, with the highest increases being expected during winter and the lowest increases during spring (Moseley et al., 2012). Warm periods are anticipated to increase by approximately 50% for the period of 2071 to 2100. Besides rising environmental temperatures, increasing milk yields result in further increasing metabolic heat production of dairy cows. The zone of thermoneutrality shifts to lower temperatures as milk yield, feed intake, and metabolic heat production increases (Kadzere et al., 2002). As reported by Berman (2005), a shift in the daily milk yield from 35 to 45 kg/d leads to a higher sensitivity to thermal stress and reduces the threshold temperature for intermediate heat stress by 5°C. Under subtropical and tropical climatic conditions, several studies demonstrated the effects of environmental factors (temperature, relative humidity, solar radiation, and wind speed) on the productivity of beef and dairy cattle (West, 2003; Berman, 2005; Rhoads et al., 2009). These studies associated heat stress with decreases in productivity, such as decreasing DMI, milk yield, and reproductive performance. But studies on heat stress effects in temperate zones are rarely found. The temperature-humidity index (**THI**) is a commonly used indicator of thermal conditions and the degree of heat stress and incorporates the effects of ambient temperature as well as relative humidity (Yousef, 1987; Hubbard et al., 1999). According to Rhoads et al. (2009),

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the DMI and milk yield is lower in heat-stressed cows than in cows that are kept in a thermoneutral environment. In Germany, Brügemann et al. (2012) indicated a milk yield decline between 0.08 and 0.26 kg for each unit increase in THI unit, depending on the region. In addition to declines in feed intake and milk yield, significant decreases in milk components (protein and fat) and increases in SCS have been demonstrated in the hottest months of the year (Rodriquez et al., 1985; Bouraoui et al., 2002). Quist et al. (2008) reported seasonal differences between summer and winter in fat and protein yield for the first lactation. As already pointed out for the milk components, a seasonal pattern is also observed for SCS. Generally, SCS increases during the summer months (Norman et al., 2000; Bouraoui et al., 2002; Olde Riekerink et al., 2007).

Worldwide, dairy cows are kept in various production and housing systems (Schnier et al., 2003; Nardone et al., 2010). However, the extent to which these systems affect heat stress effects on dairy cows is unknown. According to Nardone et al. (2010), production systems can be divided into 3 main categories: (1) grazing or pastoral systems, (2) mixed agro-zootechnical or crop-livestock systems, and (3) industrial or landless systems. In Central and Eastern Europe, mixed livestock systems dominate, whereas grazing systems are only found in distinct areas. In Lower Saxony, one-third of the cattle farms keep their cows in tied stables and two-thirds in loose-housing systems (German Federal Statistical Office, 2010). However, the number of loose-housing systems is increasing (Zähner et al., 2004). Schnier et al. (2004) classified loose-housing systems into warm and cold loose-housing systems according to the climatic conditions inside the barn. Whereas in cold loose-housing systems, the microclimatic conditions inside the barn are similar to the macroclimatic conditions outside (Schnier et al., 2003), warm loose-housing systems are characterized by relatively constant climatic conditions in the barn throughout the year (Schnier et al., 2004). Another important aspect in dairy husbandry is pasturing. About two-thirds of the 783,000 dairy cows in Lower Saxony were kept on pasture for an average of 24 wk/yr in 2009 (German Federal Statistical Office, 2010). Overall, the husbandry system has a substantial effect on the climatic conditions in dairy barns. In addition to other factors (e.g., nutrition, health status, parity, stage of lactation, and season of calving), the microclimatic conditions affect the performance of animals (Ziegler and Weniger, 1990; Gader et al., 2007).

Considering rising temperatures and the availability of different housing systems, the aim of this study was to evaluate heat stress effects on milk production traits and SCS in different housing systems in Lower Saxony, Germany.

MATERIALS AND METHODS

Animals and Housing Systems

The study was conducted on 20 dairy farms distributed over Lower Saxony, Germany. Herd sizes varied between 70 and 200 Holstein-Friesian cows raised in loose-housing systems with cubicles. Four different housing systems were differentiated: (1) warm loose housing with access to grazing (**WG**), (2) warm loose housing without access to grazing (**WI**), (3) cold loose housing with access to grazing (**CG**), and (4) cold loose housing without access to grazing (**CI**). In the 2 pasturing systems, WG and CG, cows had access to pasture from May to October. Cold and warm loose-housing systems differed by the construction of the roofs, with warm having insulated and cold loose-housing systems having non-insulated roofs. Five farms belonged to each of the 4 different housing systems.

Milk Production Traits and SCS

A total of 21,546 test-day records for milk yield, fat, and protein percentage, and SCC collected from April 2010 to March 2011 were included in the study. The data set comprised 5,070 test-day records from WI, 4,106 from WG, 6,824 from CI, and 5,546 from CG. Milk yield and fat percentage were used to calculate FCM (4%) yield. Fat and protein yield were calculated from milk yield and fat and protein percentage, respectively. Somatic cell score was calculated as $\log_2$ (SCC/100,000) + 3. Lactation was divided into 3 stages: early (0 to 100 DIM; 7,689 test-day records), mid (101 to 200 DIM; 7,276 test-day records), and late (201 to 305 DIM; 6,580 test-day records). Parity was divided into 3 classes: first lactation, second lactation, and $\geq$3 lactations. Seasons of calving were defined as follows: spring (March to May), summer (June to August), autumn (September to November), and winter (December to February).

In addition to the test-day records, bulk milk samplings were collected during the study period on 4 of the 5 farms of each housing system. Each farm was sampled 4 to 6 times per month and bulk milk was analyzed for fat and protein percentage, and SCS.

Environmental Data

Ambient temperature and relative humidity within the barns were recorded at 15-min intervals by data