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Effect of short- and long-term heat stress on the conception risk of dairy cows under natural service and artificial insemination breeding programs

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ABSTRACT

The objectives of this retrospective study were to examine the effect of heat stress on natural service and artificial insemination (AI) breeding methods. We investigated the influence of short- and long-term heat stress on the conception risk (CR) of dairy cows bred by natural service or by AI with frozen-thawed or fresh semen. In addition, the relationship between breeding method and parity was determined. Cows bred by AI with frozen-thawed semen exposed to long-term heat stress (mean temperature-humidity index ≥73 in the period 21 d before breeding) were 63% less likely to get pregnant compared with cows not exposed to heat stress. Cows bred by AI with fresh semen were 80% less likely to get pregnant during periods of short-term heat stress than during periods without heat stress. Furthermore, multiparous cows bred by AI with frozen-thawed or fresh semen were 22 and 67% less likely to get pregnant, respectively, than primiparous cows. No influence of heat stress or parity was noted on the CR of cows bred by natural service. The present study indicates that the likelihood of dairy cows becoming pregnant is reduced by short- and long-term heat stress depending on the type of semen employed. In particular, CR of cows inseminated with fresh semen is negatively affected by short-term heat stress and CR of cows inseminated with frozen-thawed semen is negatively affected by long-term heat stress.
Key words: heat stress, conception risk, artificial insemination, natural service, dairy cow

INTRODUCTION

Heat stress can have major effects on fertility and embryonic survival in lactating dairy cows (Hansen and Arechiga, 1999). These include disturbances in hormonal balance (Wilson et al., 1998; Roth et al., 2000), decreased follicle and oocyte quality (Wolfenson et al., 1995; Roth et al., 2000), and decreased embryo development and embryo survival (Wolfenson et al., 2000; De Rensis and Scaramuzzi, 2003). These processes lead to a decrease in conception rate during periods of heat stress ranging between 30 and 60% compared with periods without heat stress (De Rensis et al., 2002; Schüller et al., 2014). Even in temperate climates, conception rate of dairy cows decreases from 31% during cold climate conditions to less than 13% during periods of heat stress (Schüller et al., 2014).

Furthermore, reproductive performance of bulls is negatively affected by heat stress, resulting in reduced libido and sperm motility and an increased number of abnormal sperm (Nichi et al., 2006; Menegassi et al., 2015). Generally, ambient temperatures in the range of 5 to 15°C were found to be optimal for semen production (Parkinson, 1987; Fuerst-Waltl et al., 2006). In a study conducted in a temperate climate, a negative relationship between ambient temperature in periods of 11 and 65 d before sperm collection and percentage of viable spermatozoa and sperm motility was detected (Fuerst-Waltl et al., 2006).

Reduced reproductive performance of dairy cows in combination with reduced libido and semen quality of bulls during summer months can cause important economic losses to the dairy industry (Collier et al., 2006). Therefore, the breeding method used in periods of heat stress should be considered to maximize reproductive performance. As a result of impaired reproductive performance, AI has become popular, and AI upon natural estrus is still the most prevalent method to breed cows for first and subsequent services (Overton and Sischo, 2005; National Animal Health Monitoring System, 2009). In contrast to natural service, it is assumed that a decrease in semen quality due to heat stress can be avoided in AI breeding programs by the use of frozen semen (Hansen and Arechiga, 1999). Natural service bulls, however, have been considered as a profitable alternative for managing dairy herds when estrus-detection rates are abysmal during summer months (Jobst et al., 2000); therefore, natural service continues to be a popular component of the breeding system in

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many dairy herds (de Vries et al., 2005). Furthermore, in European dairy farms, it is common practice to breed repeat breeder cows and cows with reproductive issues by natural service. Few studies have compared reproductive performance between AI and natural service breeding systems during periods of heat stress, and none have done so in a temperate climate. Niles et al. (2002) found pregnancy rates of dairy cows bred by AI or natural service did not differ significantly during the hot season, although the level of heat stress was not assessed. In contrast, de Vries et al. (2005) reported lower pregnancy rates for AI-breeding herds than for natural service and combined breeding herds during periods of heat stress. In contrast, a dearth of information exists on the effect of different periods of heat stress on AI and natural service breeding programs. Finally, we found no documentation of the effect of heat stress on AI compared between frozen-thawed or fresh semen. Thus, the objective of our study was to determine the influence of short- and long-term exposure to heat stress on the conception risk (**CR**) of lactating dairy cows in different breeding programs. Furthermore, the relationship between breeding method and parity was determined.

MATERIALS AND METHODS

Design of the Barn

The retrospective study was conducted on a commercial dairy farm in Sachsen-Anhalt, Germany, from May 2010 to October 2012. The herd consisted of 1,150 Holstein dairy cows with an average milk production of 10,345 kg (4.0% fat, 3.3% protein). The barn was positioned in a northeast-southwest orientation (51°77′N, 12°91′E) with open ventilation and a mechanical fan system. Sixty fans were installed above the stalls and controlled manually by the farm manager. All cows were housed in a freestall facility with slatted floors and beds equipped with rubber mats. Group composition was dynamic, with cows entering and leaving the study barn depending on their calving dates. Cows were fed a TMR. The rations were formulated to meet or exceed the requirements of the NRC (2001). Lactating cows were milked 3 times a day at starting at 0600, 1400, and 2200 h.

Reproductive Management

The voluntary waiting period was set at 55 d postpartum. Between 35 and 49 d, cows received an initial injection of 25 mg of $PGF_{2\alpha}$ (Dinoprost, Dinolytic, Zoetis Deutschland GmbH, Berlin, Germany) and a second injection of 25 mg of $PGF_{2\alpha}$ 2 wk later to regress the corpora lutea. Cows that showed estrus after the second injection of $PGF_{2\alpha}$ were AI or received natural service by a bull. Natural service was provided for all cows after caesarean section, with adhesions of the uterus and repeat breeder cows in third or higher lactation. Pedometers (Milkline, Gariga di Podenzano, Italy) and visual observation were used to detect estrus. Cows that did not show estrus after the second injection of $PGF_{2\alpha}$ within 3 d were excluded from the analysis. Inseminations were performed by 7 technicians within 12 h after detection of estrus with frozen-thawed or fresh semen from bulls (n = 219) used randomly across inseminations depending on the availability of semen in fresh or frozen state. Pregnancy diagnoses were performed 35 to 42 d after the day of breeding with transrectal ultrasonography by the herd veterinarian. Cows with unclear pregnancy diagnosis were reexamined with transrectal ultrasonography 1 wk later. Cows that were diagnosed not pregnant were reassigned to breeding with natural service or AI with frozen-thawed or fresh extended semen depending on the results of the transrectal ultrasonography and the number of previous inseminations. Cows that were observed in estrus >10 d after AI were assumed nonpregnant and reinseminated.

Frozen-thawed and fresh semen used for AI in this study was processed by the local AI center and sent daily to the dairy farm. Frozen semen was stored in 0.25-mL straws within liquid nitrogen at −196°C. During the course of thawing, semen samples were taken out of the liquid nitrogen and thawed in a water bath at 37°C for 30s. Fresh semen was stored in thermoinsulated canisters at 10 to 15°C until insemination.

Data Collection

Ambient temperature and relative humidity within the experimental barn were recorded using a Tinytag Plus II logger (Gemini loggers Ltd., Chichester, UK) secured at a beam 3 m from the ground within the barn. This logger measured ambient temperature from −25 to 85°C, with an accuracy of ±0.3°C and a resolution of 0.01°C, and relative humidity from 0 to 100%, with an accuracy of ±3% and a resolution of 0.3%. These data were recorded hourly. Ambient temperature (AT) and relative humidity (RH) data were used to calculate the temperature-humidity index (**THI**) according to the equation reported by the NRC (1971): $THI = (1.8 \times AT + 32) - [(0.55 - 0.0055 \times RH) \times (1.8 \times AT - 26)]$. Cow identification, parity, service dates, breeding method, number of services, and results of pregnancy diagnosis were obtained from computerized herd records managed using Herde (Version 5.5, Software Projektierungs- und Handels GmbH, Aschare, Germany).