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Evaluation of floor cooling on lactating sows under mild and moderate heat stress[1]

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ABSTRACT

The effectiveness of sow cooling pads during lactation was evaluated under mild and moderate heat stress conditions. The moderate heat stress room was targeted to achieve 32°C from 0800 to 1600 h and 27°C for the rest of the day. The mild heat stress room was targeted to achieve 27 and 22°C for the same periods, respectively. Sows received a constant cool water flow of 0.00 (CON, n = 9), 0.25 (LWF, n = 12), or 0.50 (HWF, n = 10) L/min. Respiration rates, rectal temperatures, and skin temperatures were recorded every day (0700 and 1500 h) from the second day in the farrowing room to weaning. The respiration rates of CON sows were 23, 56, 41, and 89 breaths/min, of LWF sows were 21, 24, 29, and 41 breaths/min, and of HWF sows were 18, 20, 24, and 27 breaths/min, and respiration rate increased ($P < 0.001$) as heat stress increased from mild at 0700 h (22°C), to moderate at 0700 h (27°C), to mild at 1500 h (27°C), and to moderate at 1500 h (32°C). The skin temperatures of LWF sows were 1.1, 0.6, 0.8, and 0.4°C less and of HWF sows were 1.7, 0.7, 1.1, and 1.0°C less ($P < 0.01$) than CON sows for the same heat stress conditions. The rectal temperatures of LWF sows were 0.02, 0.20, 0.11, and 0.58°C less and of HWF sows were 0.04, 0.22, 0.02, and 0.57°C less ($P < 0.05$) for the same 4 treatments. The sow cooling pads reduced the effect of heat stress.

Key words: cooling pad, heat stress, lactation, sow, floor cooling

INTRODUCTION

High environmental temperatures cause lactating sows to reduce their feed intake and milk production to reduce their internal heat production (Black et al., 1993; Spencer et al., 2003). This results in reduced piglet growth and weaning weights (Quiniou and Noblet, 1999). In addition, heat stress reduces sow fertility because reduced feed intake has negative effects on body condition (Koketsu et al., 1996; Prunier et al., 1997). The combination of reduced sow productivity, piglet growth, and sow fertility in response to seasonal increases in temperature results in an annual loss of over $360 million for the United States pork industry (St-Pierre et al., 2003). On a worldwide basis, heat stress has a substantial effect because many pigs are produced in tropical areas of the world.

Genetic selection for increased litter size and milk production has resulted in increased heat production in current sows with a reduction of their upper critical temperature to approximately 18°C (Quiniou and Noblet, 1999; Cabezón et al., 2017a,b). To achieve the increased performance in sow productivity produced by genetic selection for milk production and litter size while minimizing BW loss during lactation, some of the excess heat must be removed.

Current technologies employed to cool lactating sows include both drip cooling and snout cooling combined with increased ventilation rates (Barbari et al., 2007). Research conducted with floor pad cooling in comparison with drip and snout cooling found a preference for floor cooling (Bull et al., 1997). Other studies found that floor cooling enhanced sow productivity and reproductive performance through the removal of excess heat produced by lactating sows (Silva et al., 2006, 2009; van Wagenberg et al., 2006).

Recently, a cooling pad has been designed to remove increased amounts of excess heat produced by modern sows (Cabezón et al., 2017b, 2018a,b) and has been tested in short duration trials of acute heat stress. However, studies have not been undertaken to assess the effect of these new cooling pads throughout an entire farrowing-lactation period and to what extent measures of physiological heat stress vary within a day. The objectives of this research were (1) to evaluate the effectiveness of the cooling pads

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over an entire lactation period and (2) to evaluate the heat removal capacity of cooling pads within a day.

MATERIALS AND METHODS

Animals, Housing, and Treatments Groups

The Purdue University Institutional Animal Care and Use Committee approved all animal research and management procedures. This study was conducted in the farrowing facility at Purdue University Animal Science Research farm. The farm is located in a humid continental climate with a warm summer (40°29′59″N and 87°00′47″W, with an altitude of 218 m), classified as Dfa (Köppen, 1948). The trial was performed from November 21, 2016, to February 17, 2017.

Thirty-one commercial crossbred Yorkshire and Landrace sows with a mean parity of 3.5 (SD = 1.8) were moved to the farrowing house in 2 batches of 16 and 15 sows (2 farrowing groups). The animals were distributed, blocked by parity and BW, in 2 farrowing rooms that differed only with respect to imposed environmental conditions. Sows were housed in individual farrowing crates, and each sow was provided with a cooling pad. Treatments were randomly allotted to sows in each room to receive a constant cool water flow of 0.00 (**CON**, n = 9), 0.25 (**LWF**, n = 12), and 0.50 (**HWF**, n = 10) L/min during the entire lactation. The cooling water flow rates were previously evaluated under acute heat stress conditions and expected to be adequate to affect the physiological effect of mild to moderate heat stress (Cabezón et al., 2017b).

Environmental conditions were controlled in each room to simulate a moderate or mild heat stress. Each room had one heater and one fan. The heater in the moderate heat stress room was set to achieve 32°C from 0800 to 1600 h and 27°C for the rest of the day (CON, n = 5; LWF, n = 6; and HWF, n = 6). The heater in the mild heat stress room (27–22°C) was set to achieve 27°C from 0800 to 1600 h and 22°C for the rest of the day (CON, n = 4; LWF, n = 6; and HWF, n = 4). In both rooms, the fan (fan and screen opening of 0.41 × 0.41 m and 0.48 × 0.46 m, respectively) was running at 100% speed during the entire trial, and the screen opening was reduced to 40% to reduce the heat loss due to the ventilation system. Temperature, relative humidity, and dew point were recorded in 5-min intervals using 2 data loggers (accuracy: ±0.5°C, 3%, and 1.1°C for temperature, relative humidity, and dew point, respectively, EL-USB-2, DATAQ Instruments Inc., Akron, OH) in each farrowing room. The data loggers were tested under a range of temperatures in comparison with a scientific thermometer. The data loggers were placed 0.7 m from the floor at the sow level and away from water sources.

From arrival to the farrowing room to d 1 of lactation, sows were fed 2.75 kg/d. After d 1 of lactation, sows had ad libitum access to feed. The diet was based on corn and soybean meal, formulated to meet or exceed nutrient requirements (0.9% standard ileal digestible lysine, NRC, 2012). Feed was given twice daily at 0630 and 1430 h. All sows had ad libitum access to water. Piglet processing (ear notching, tail docking, castration, teeth clipping, and supplemental iron injection) was performed during the first 48 h postpartum. Piglet cross fostering was allowed only during the first 48 h after processing. Litter size was standardized to approximately 10 or more piglets per sow (mean = 11.5 ± 1.7). Heat lamps were provided to keep the piglets warm. Lactation length was on average 18.4 ± 1.9 d.

Respiration Rate and Rectal and Skin Temperatures

Respiration rates (**RR**), rectal temperature (**RT**), and skin temperature (**ST**) were recorded every day (0700 and 1500 h) from the second day in the farrowing room to weaning. Recording of morning and afternoon RR, RT, and ST on the first and second day at the farrowing room was done to establish basal values.

A more intensive study of the RR, RT, and ST was performed on sows in the moderate heat stress room and on the CON (n = 3) and HWF (n = 3) flow rate treatments during 2 d (14.2 ± 1.8 d of lactation) of the second farrowing group replicate. Respiration rate, RT, and ST were recorded at 0600, 0700, 0730, 0800, 0830, 1100, 1400, 1500, 1530, 1600, 1630, and 1900 h.

Respiration rates were recorded as the number of breaths (flank movement) counted in 30 s. The number of breaths per minute was computed as 2 times the observed number of breaths. A minimum of 2 observations were recorded for each sow for every measurement.

Rectal temperatures were recorded with a high-speed digital thermometer with a 9.5-cm probe (accuracy: ±0.2°C, Cooper Atkins TM99A, Middlefield, CT) inserted into the rectum approximately 6 cm for at least 15 s. Skin temperatures were recorded with an infrared spot thermal camera (accuracy: ±1.5°C, FLIR TG-165, Wilsonville, OR) focused on the skin 15 cm behind the ear for approximately 5 s at 30 cm from the sow, as described by Schmidt et al. (2013). The digital thermometer and the infrared camera readings were calibrated before and at the end of the trial under ice bath and boiling water conditions.

Equipment and Heat Removal Calculation

Each sow was provided with a cooling pad made with an aluminum diamond plate on the top, a high-density polyethylene base, and 8 copper water pipes (Cabezón et al., 2017b, 2018a,b). Each cooling pad had an outlet valve to regulate the water flow and an inlet valve to take water samples. Each valve was provided with a hose to collect water in a cup.

Water flow rate, inlet water temperature, and outlet water temperature were recorded every day at 0800 and 1600