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Effects of shaded versus unshaded wallows on behavior, performance, and physiology of the outdoor lactating sow

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Abstract

The objectives of this study were to determine the effects of shading wallows during the summer months on lactating sow behavior, performance, and physiology. A total of 128 sows were used during warm weather (May to August 2001) to determine the effects of unshaded (control; n = 8) vs. shaded (SH; n = 8) wallows. Sows ranged over 6 parities and were fed a completely balanced sorghum-based diet. Behavioral data were collected by 15-min scan samples over a 24-h period/wk for a total of 16 wk. All sows were observed twice when litter age was 5 and 15 d, respectively. Respiration rates (breaths/min) were collected on 50 sows (control, n = 25; SH, n = 25) over an 8-wk period when the maximum temperature exceeded 32°C. Ten milliliters of clotted blood and 20 mL of whole blood were obtained by jugular puncture from each sow on the day of weaning to determine total white blood cells, acute phase proteins, packed-cell volume, and chemotaxis and chemokinesis. Descriptive water temperature profiles were measured by using data loggers positioned at 3 levels per wallow: surface water, shallow mud, and deep mud. Behavioral, postural, location, performance, and physiological measurements did not differ ($P > 0.05$) among wallow treatments. Regardless of treatment, sows spent approximately 82% of their total time budget inside the farrowing hut and only approximately 7% of their total time budget in the wallow. A total of 428 piglets died, 219 in the control treatment and 209 in the SH treatment. The majority of piglets in both treatments died of crushing within the first 72 h after parturition, and most of the piglets had suckled. Shade kept the shallow water profile cooler during the hotter afternoon temperatures compared with the control wallows. In SH for both the shallow and deep mud profiles, temperatures were consistent throughout the day. In conclusion, sows spent a large percentage of their daily time budget inside the farrowing hut and spent only brief episodes in the wallow. Shading the wallow did not result in increased wallow use time or improvements in sow physiology and overall performance.

Keywords

Behavior, heat stress, performance, physiology, sow

Disciplines

Agriculture | Animal Sciences | Meat Science

Comments

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Effects of shaded versus unshaded wallows on behavior, performance, and physiology of the outdoor lactating sow[1,2]

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ABSTRACT: The objectives of this study were to determine the effects of shading wallows during the summer months on lactating sow behavior, performance, and physiology. A total of 128 sows were used during warm weather (May to August 2001) to determine the effects of unshaded (control; n = 8) vs. shaded (SH; n = 8) wallows. Sows ranged over 6 parities and were fed a completely balanced sorghum-based diet. Behavioral data were collected by 15-min scan samples over a 24-h period/wk for a total of 16 wk. All sows were observed twice when litter age was 5 and 15 d, respectively. Respiration rates (breaths/min) were collected on 50 sows (control, n = 25; SH, n = 25) over an 8-wk period when the maximum temperature exceeded 32°C. Ten milliliters of clotted blood and 20 mL of whole blood were obtained by jugular puncture from each sow on the day of weaning to determine total white blood cells, acute phase proteins, packed-cell volume, and chemotaxis and chemokinesis. Descriptive water temperature profiles were measured by using data loggers positioned at 3 levels per wallow: surface water, shallow mud, and deep mud. Behavioral, postural, location, performance, and physiological measurements did not differ ($P > 0.05$) among wallow treatments. Regardless of treatment, sows spent approximately 82% of their total time budget inside the farrowing hut and only approximately 7% of their total time budget in the wallow. A total of 428 piglets died, 219 in the control treatment and 209 in the SH treatment. The majority of piglets in both treatments died of crushing within the first 72 h after parturition, and most of the piglets had suckled. Shade kept the shallow water profile cooler during the hotter afternoon temperatures compared with the control wallows. In SH for both the shallow and deep mud profiles, temperatures were consistent throughout the day. In conclusion, sows spent a large percentage of their daily time budget inside the farrowing hut and spent only brief episodes in the wallow. Shading the wallow did not result in increased wallow use time or improvements in sow physiology and overall performance.

Key words: behavior, heat stress, performance, physiology, sow

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INTRODUCTION

The welfare of the lactating sow kept outdoors in summer climates that exceed 32°C may be compromised unless she is assisted in thermoregulation. Adaptive behaviors performed by the lactating sow may involve postural changes and wallowing (Blackshaw et al., 1994). Sows have been reported to wallow when environmental temperatures exceed 12°C, especially after eating, when in estrus, or when experiencing a fever (Curtis, 1985). Furthermore, under natural conditions, feral sows have been observed to alter their behavioral pattern by seeking shelter during the daytime hours and then becoming increasingly active during the cooler night hours (Ingram, 1976). Both indoor- and outdoor-housed lactating sows show adverse effects to prolonged periods of heat stress in terms of performance and behavior (Edwards et al., 1968; McGlone et al., 1988), physiology (Bull et al., 1997), and immune function (Morrow-Tesch et al., 1994). These behavioral, physiological, and performance alterations may adversely affect the wel-

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fare of the piglets and the overall profitability for the producer. Two studies have considered the potential benefits of shading wallows for grower pigs (Heitman et al., 1959; Garrett et al., 1966), but no research has been conducted with lactating sows kept outdoors. The objectives of this study were to determine the effects of shading wallows during the summer months on lactating sow behavior, performance, and physiology.

MATERIALS AND METHODS

Animals were kept and used in accordance with the Guide for the Care and Use of Agricultural Animals Used in Agricultural Research and Teaching (FASS, 1999), and the project was approved by the Texas Tech University Animal Care and Use Committee.

Animals and Location

A total of 128 lactating sows (Camborough-22, PIC USA, Franklin, KY) and their litters were used. Sows used for this study had a good health status (negative for pseudorabies, brucellosis, porcine respiratory and reproductive virus syndrome, and mycoplasmal hyopneumonia). Sows ranged over 6 parities: parity 2 (n = 22), 3 (n = 23), 4 (n = 21), 5 (n = 17), 6 (n = 32), and 7 (n = 13). All animal measures were collected from May until August 2001 at the Sustainable Pork Farm, which is situated in an area near Lubbock, Texas, with a dry steppe climate producing mild winter temperatures. Ambient temperatures were recorded by using a weather station (Weather Monitor II, model 7440, Davis Instruments, Baltimore, MD) located on site. Weather measurements taken were outdoor temperature in degrees Celsius, percent relative humidity, total precipitation (cm), and wind velocity (km/h). Measurements were recorded at 10-min intervals. Throughout the trial, average temperatures were 25.15°C and relative humidity was 50.83%, resulting in a temperature-humidity index of 71.98. Average wind velocity was 18.1 km/h, with a total precipitation of 6.9 cm.

Housing, Diets, and Husbandry

Sows remained outdoors during breeding, gestation, and farrowing. All sows were artificially inseminated and checked for pregnancy 4 wk later by using real-time ultrasound. Pregnant sows were then moved into a gestation paddock. Sows were gestated over time in groups that contained 16 sows per gestation paddock. Within these gestation groups, sows were of mixed parity and were kept in the same social group through both the gestation phase and the farrowing phase. Five days before scheduled farrowing, gestation sows were transferred to the farrowing paddock, and this larger gestation group was split into 2 smaller farrowing groups containing 8 sows per group per farrowing paddock. Sows entering farrowing were randomly assigned to an unshaded (control) or shaded wallow (**SH**) treatment. In each paddock, English-style arc farrowing huts were used to house 1 sow and her litter (McGlone and Hicks, 2000; Johnson and McGlone, 2003). Each day, new straw was provided to the litters that were 10 d of age or less. For older litters, straw was added twice weekly or as required. One wallow per farrowing paddock was built before the arrival of the sows. The wallows were situated in an east-west orientation. Initial wallow dimensions were 5.4 × 0.90 × 0.3 m. To create the shade, frames over the wallow were 7.3-cm-diameter hollow steel pipes. Frame dimensions were 1.5 m height × 3.6 m width × 4.8 m length). Black polypropylene shade cloth (80% light occluding) was spanned across the top of the frame and secured by using plastic ties. Once daily at 0800 h, sows were fed a completely balanced sorghum-based diet (CP 16%; 1,535 kcal of ME/kg; lysine 0.95%) in a designated strip area along one side of the perimeter fence. Depending on the stage of lactation, sows were fed the appropriate amount of feed (2 to 9 kg/d; NRC, 1998). Sows had unrestricted access to clean drinking water, and a wallow was available for thermoregulation. Piglets were not provided with creep feed, but did have access to ground cover. The predominant ground cover was WW-Spar blue stem (*Bothriochloa ischaemum*), which was planted on site. Every sow and her litter were checked twice daily for health, dead piglets, or farrowing problems. Piglets in both treatments were processed (which included tail docking, ear notching, and castration) and were weaned at 25.5 ± 0.4 d for control piglets and 26.3 ± 0.4 d for SH piglets.

Performance

Piglets were counted and weighed at birth and weaning. The total number of piglets per litter was further divided into piglets born alive, mummies, and stillbirths as defined previously by Johnson et al. (2001). Preweaning piglet mortality was defined as any piglet that was born alive but that died before weaning. Age, sex, BW, and primary and secondary causes of preweaning piglet mortality were determined by 1 experienced observer via internal and external necropsy of the heart, lungs, stomach, and skin on the day of death. Four categories were used to determine preweaning mortality: 1) starvation, when the stomach and intestines contained no milk residues; 2) starvation and crushed or stepped on, if the piglet displayed one or more of the following: bruising to the body, excessive blood in the heart and lungs, protrusion of internal organs from the body cavity, and no milk residues in the stomach or intestines; 3) suckled and crushed or stepped on, which was the same as above except that milk residues were present in the stomach, intestines, or both; and 4) other, which included killed (i.e., the caretaker had to kill the piglet immediately on removing a live piglet from the farrowing hut), exposure (the piglet was found outside the farrowing hut), drowned (the piglet was found in the wallow and had water in the lungs), or unknown. Piglets that were born and that were not allocated to the preweaning category were classified as missing. Days of lactation were calculated for each sow by subtracting the day she farrowed from the day she weaned. In addition, the breeding manager recorded the time required for the sow to return to estrus.

Behavior

Postures measured were standing, inactive (lying and sitting), and walking. Three behaviors were recorded [feeding, head down (rooting and grazing), and drinking], as well as the total amount of time spent by the sows in a location (pasture, wallow, or farrowing hut). A behavioral validation study was conducted to validate the live observations by using a 15-min scan sample over a 24-h period (0700 to 0700 h) once a week (Johnson and McGlone, 2008). Night observations were made possible by using night vision viewers (model F5000 series, Optics Planet, Roanoke, VA). Every sow was observed twice when the average ages of piglets in the paddock were 5 and 15 d.

Physiology

Respiration Rate. Once a week (except on the days behavioral data were collected) for 8 wk, between 1600 and 1700 h, respiration rates (**RR**) were taken for 50 sows (n = 25, control; n = 25, SH) while they were lying in the wallow. This time period was chosen because maximum average temperatures for the week preceding the RR readings were above 32°C. Binoculars were used to count RR from a distance of 5 m from the wallows to ensure that sows were not disturbed. One respiratory cycle was defined as the sow inhaling and exhaling once. Sow flank movements were counted for 1 min. Respiration rates were averaged for each observation day and were plotted against the actual temperature at observation time.

Immunity Measures. Ten milliliters of clotted blood and 20 mL of whole blood containing 72 US Pharmacopeia units of sodium heparin were obtained by jugular puncture from each sow (n = 110) on the day of weaning. The blood was submerged in ice and within 60 min of collection was transferred to the laboratory. Blood samples were centrifuged for 30 min at $750 \times g$ to separate plasma and serum, from whole blood and clotted blood, respectively. Both were stored frozen (−20°C) in plastic 1.8-mL vials until assays were conducted. White blood cell counts and differential cell type were determined by using a Cell Dyne instrument (Abbott Labs, Santa Clara, CA). Packed-cell volume was determined from whole blood. Twenty microliters of whole blood was collected into a 40-mm Statspin microhematocrit tube (Statspin Technologies, Norwood MA) containing ammonium heparin and read by using a CritSpin Digital Reader (model CS22, Iris, Sample Process, MA). Porcine α_1-acid glycoprotein and porcine haptoglobin concentrations were determined by using a radial immunodiffusion test kit (Cardiotech, Louisville, KY) with previously described methodologies from this laboratory (Hicks et al., 1998). The linear regression equation for porcine α_1-acid glycoprotein was y = 201.6 − 851.41 ($r^2 = 0.99$), and for porcine haptoglobin it was y = 207.25 − 857.08 ($r^2 = 0.99$). Neutrophil chemotaxis and chemokinesis were determined by methods described previously by McGlone et al. (1993), Salak-Johnson et al. (1996), and Hulbert and McGlone (2006). Five fields per well of the cells that migrated to the underside of the filter were counted in a blind fashion at 1,000× magnification (McGlone and Fullwood, 2001).

Wallow Temperature Variables

In July 2001, the temperatures in 8 wallows (control, n = 4; SH, n = 4) were recorded by using 3 data loggers (Hobo Pro series, Hobo, Janesville, WI) per wallow. Each data logger was vacuum-sealed and fixed onto an iron rod at 1 of 3 levels: 1) water surface level, 2) shallow mud (30 cm depth), or 3) deep mud (1 m) below the water level. Water, shallow mud, and deep mud ambient temperatures were recorded at 10-min intervals, and measures were then averaged on an hourly basis. Water and mud temperature data were provided for descriptive purposes.

Statistical Analysis

Analyses were performed by using PROC GLM (SAS Inst. Inc., Cary, NC) for parametric data. The experimental unit was the individual farrowing paddock (n = 8 per treatment) containing one lactating sow each. Two treatments were compared: SH or control. Each treatment was represented monthly (May through August) with the entry of sows into the trial for behavioral, performance, and physiological variables (total of 128 sows). Respiration rates were recorded for 50 sows for a total of 8 wk. All behavioral data were expressed as percentages and were subjected to an arcsine square root transformation process to achieve a normalized distribution. Behavioral percentage data were averaged over a 24-h period to remove the daytime effect. The statistical data for behavioral, performance, and physiological variables were analyzed as a mixed model randomized block design. Parity of the sow was used as a linear covariate. Wallow treatment (SH vs. control wallows) temperature and interactions were included in the statistical analysis. No interactions were significant, and these were removed from the final analysis.

RESULTS

Performance

Wallow treatment had no effect ($P > 0.05$) on any performance variable (Table 1). Preweaning mortality was unacceptably great over both treatments (approximately 32%), with a total of 428 piglets dying before

Table 1. Least squares means and SE for the performance of lactating sows and their litters in control vs. shaded wallows from May to August 2001

	Wallow treatment			
Performance variable	Control	Shaded	SE	*P*-value
Sows and litters, n	64	64		
Piglets born, n/litter	13.1	12.3	0.4	0.21
Piglets born alive, n/litter	12.5	11.7	0.3	0.16
Stillbirths, n/litter	0.5	0.6	0.1	0.89
Mummies, n/litter	0.02	0.04	0	0.60
Litter birth wt, kg/litter	20.9	19.3	0.7	0.06
Mean litter birth wt, kg/litter	2.0	2.0	0.1	0.56
Piglet mortality, n/litter	3.3	3.4	0.4	0.89
Mortality, %	31.6	31.9	2.7	0.81
Days of lactation	25.5	26.6	0.4	0.21
Piglets weaned, n/litter	8.4	7.8	0.3	0.12
Litter weaning wt, kg/litter	60.4	55.4	2.5	0.13
Mean litter weaning wt, kg/litter	7.7	7.32	0.2	0.83
Missing piglets, n	0.8	0.6	0.2	0.58
Return to estrus, d	4.9	4.7	0.1	0.69

weaning (219 control and 209 SH). The majority of piglets in both treatments (147 control vs. 138 SH) died within the first 72 h after parturition (63% control vs. 70% SH) after parturition, and on necropsy 63% of dead piglets were found to have suckled and were crushed by the sow, 14% died from starvation and were crushed, 7% starved to death, and 2% were classified as other. Piglets from both treatments that died early were, on average, lighter (1.3 kg) than piglets that were processed at birth (2.03 kg).

Behavior

Wallow treatment (SH vs. control) had no effect ($P > 0.05$) on standing (2.8 ± 0.2%), inactivity (5.8 ± 1.1%), or walking (2.3 ± 0.3%). There was a trend ($P = 0.07$) for SH sows to engage in more feeding behaviors (3.5 ± 0.3%) compared with their control counterparts (2.8 ± 0.3%). Head down (2.5 ± 0.4) and drinking (2.1 ± 0.2%) behaviors did not differ ($P > 0.05$) between treatments. The percentage of time sows spent within a given location did not differ ($P > 0.05$) between the 2 treatments, but they clearly preferred to spend their time located within their farrowing hut (81.5 ± 1.6%) compared with the pasture (11.7 ± 1.0%) or wallow (6.9 ± 0.8%).

Physiology

Wallow treatment had no ($P > 0.05$) effect on any of the physiological variables measured. Total white blood cells (16 ± 0.5 103/μL), neutrophil-to-lymphocyte ratio (1.94), α_1-acid glycoprotein (359.1 μg/mL), haptoglobin (1,597.8 μg/mL), packed-cell volume (38.6%), and all variables were within normal ranges for the lactating sow. However, there was a trend ($P = 0.07$) for decreased RR with sows in the SH wallows (35.2 ± 0.7 breaths/min) compared with control wallows (37.1 ± 0.7 breaths/min).

Wallow Temperature Variables

Shade kept the shallow wallows slightly cooler (28°C) during the hotter afternoon (1300 to 1900 h) temperatures compared with the control wallows (31°C). The SH wallows for both shallow and deep mud profiles remained relatively unchanged throughout the day, with shallow mud being warmer than the deeper mud (28 vs. 23°C). Shallow mud temperature in the control wallows increased slightly (from 23 to 27°C) with the warmer late afternoon and early evening (1600 to 2100 h) temperatures, but the deep mud profile (24°C) was unaffected by increasing ambient temperatures (Figure 1).

DISCUSSION

Performance

Previous wallow-shading research by Heitman et al. (1959) for outdoor finisher swine reported that shading increased ADG, and for sows kept outdoors, Omtvedt et al. (1971) and Prunier et al. (1994) reported an increased interval in return to estrus with warmer temperatures. Results from this study do not indicate shading benefits for any sow or litter performance. The occurrence of mummies and stillbirths was in acceptable ranges (Randall, 1972; English and Morrison, 1984), but preweaning mortality was unacceptably great, at 32% for both treatments, with approximately 63% of the mortality attributed to crushing by the sow. Summertime preweaning mortality is typically elevated in an outdoor herd compared with indoor herds (Edwards et al., 1994; National Animal Health Monitoring System, 2000; Johnson et al., 2001). We attribute this increased preweaning mortality primarily to warm

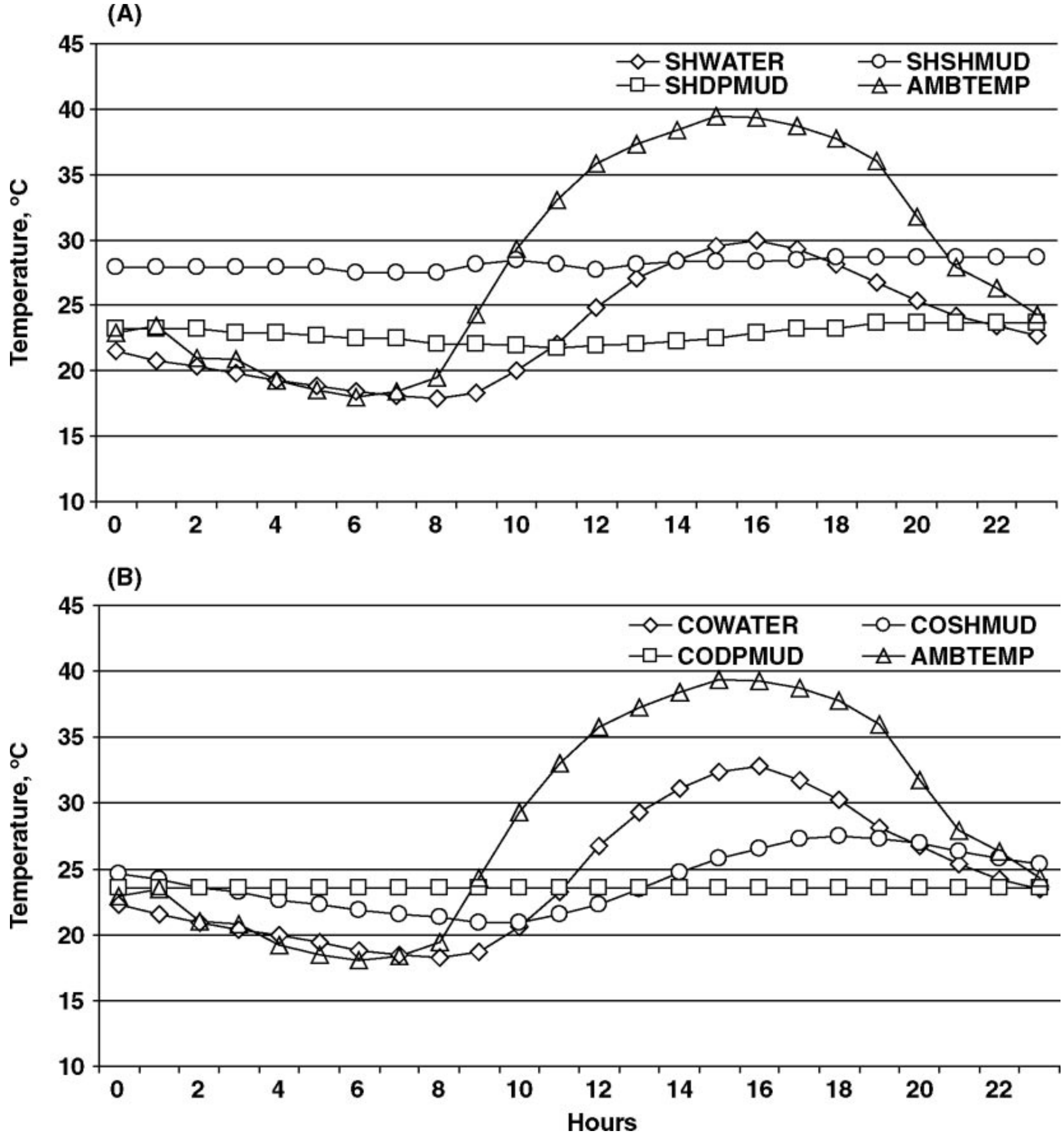

Figure 1. Temperature of shaded (A) and unshaded (B) wallows for 3 wallow profile depths: shallow water, shallow mud, and deep mud. Temperatures comparable with ambient temperature (°C) were averaged over a 24-h period (0 = midnight or 0000 h) during July 2001. SHWATER = shallow water; SHDPMUD = shade and deep mud; SHSHMUD = shade and shallow mud; AMBTEMP = ambient temperature.

ambient temperatures. The majority of piglet deaths occurred within the first 72 h, with numbers declining over subsequent days of lactation, which confirmed findings by Edwards et al. (1994). The majority of piglets were killed by the sow through crushing, and as piglets increased in age, more were found crushed in the paddock. A possible reason for this location is that piglets at approximately 10 d of age pass through a transition stage from "hiders" to "followers"; that is, they follow the sow out of the nest or farrowing hut into the pasture (Newberry and Wood-Gush, 1985). Starvation began to occur at approximately d 5 of lactation, which indicates that starvation is a slower form of preweaning mortality than crushing (Dyck and Swierstra, 1987; Higgins and Edwards, 1997). In addition, piglets that succumbed to preweaning mortality weighed less than piglets at processing, which agrees with similar findings by Gill and Thomson (1956), Tuchscherer et al. (2000), and Marchant et al. (2000).

Behavior

Behavioral processes of thermoregulation are those that involve the movements of the whole body relative to the environment, or that effect some changes in the rate of heat production or heat flow from the body (Curtis, 1985). Behavioral temperature regulation may involve postural changes, such as extension of body contact with a cooler surface or seeking shade. Sows have a large BW but a low surface:mass ratio and therefore find it more difficult to dissipate internal heat compared with smaller piglets (Hansen and Vestergaard, 1984). A few studies have reported on swine behavior in an outdoor setting. Curtis (1985) reported that sows engage in greater amounts of wallowing when outdoors, because evaporative heat exchange from the muddied side of the sows can reach 800 g/m^2 per h, which is greater than a sow sweating maximally. Blackshaw et al. (1994) observed the standing, lying, and shade-seeking behavior of boars, gestating sows, growers, and weaners with access to an outside pen. The authors observed that when ambient temperatures rose above 35°C, 99% of sows and 97% of boars were lying down in the shade. Slightly fewer weaners (85%) and growers (93%) were in the shade, and when in the shaded areas of the pens, they were more restless. The authors concluded that this behavior might be due to a lack of experience in seeking shade and comfort in hotter climates. The behavioral differences seen between the grow-finisher pig in previous studies and the lactating sows in our study may be due to different motivational priorities. For example, the growing pig eats and remains inactive for large periods of the day. The lactating sow engages in a cyclic behavioral pattern, with a central focus on nursing in and around the farrowing nest (Jensen, 1988; McGlone and Morrow-Tesch, 1990; Johnson et al., 2001). In the present study, regardless of ambient temperature or treatment, the sows spent approximately 82% of their total time budget over a 24-h period inside the farrowing hut and approximately 7% of their total time budget in the wallow area. As previously noted with the preweaning mortality levels, regardless of treatment, sows choose the farrowing hut as the preferred location. However, with the increasing heat of the day, the sow might find this microclimate uncomfortable, resulting in an increase in restless behavior and a greater preweaning mortality (Weary et al., 1996).

Physiology

To keep sows cool when housed in an indoor environment, a variety of tools can be used effectively. Some of these include misters, sprinklers, snout or evaporative coolers, and ventilation fans (Bull et al., 1997). For sows housed in an outdoor system at any stage of production, heat-stress amelioration solutions can be less straightforward, but providing shade is one possibility. Several cooling studies for indoor-housed sows have compared RR. Nichols et al. (1982) compared the value of drip-sprinkling sows to reduce heat stress during lactation with a control treatment and reported that sprinkling decreased RR, which was also noted by Kelley and Curtis (1978) and King et al. (1972). In our study, although the differences were not significant between groups, the RR followed a pattern similar to the ones seen in these previous studies. Sows in the SH (35.2 ± 0.7 breaths/min) treatment had decreased RR than sows with control wallows (37.1 ± 0.7 breaths/min), respectively. Wallow treatments did not affect any other physiological measurements collected.

Wallow Temperature Variables

The wallow profile temperatures yielded extremely interesting descriptive information. The water in the unshaded wallow reached 33°C during the hotter times in the afternoon and 30°C for SH. Sows when entering wallows were noted to root and cover themselves in mud, rather than standing, drinking the water, or both. Shallow mud temperatures overall were warmer for the unshaded vs. SH wallows, and for both treatments, the deep mud profiles remained fairly consistent over the 24-h period, at 24°C. At the hottest times of the day (1300 to 1800 h), the deep mud in both treatments was approximately 16°C cooler than the ambient temperature.

In conclusion, shading the wallow for lactating sows housed outdoors in West Texas did not offer any benefits for the lactating sow, her litter, or the producer. The preferred location for the sow was not the wallow but the farrowing hut (where piglets reside). This can result in unacceptably great preweaning mortality rates throughout the summer months. Therefore, alternative strategies to cool outdoor lactating sows need to be discovered.

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