Effect of hot weather on microclimatic parameters in stable for sows

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Abstract. The objective of this work was to evaluate the effect of hot summer weather on microclimatic parameters in the stable for mated and pregnant sows without and with using of evaporative cooling. Sows were housed in strawless gestation crates. Exhaust cross-ventilation was used in the stable. The high-pressure system was used for evaporative cooling. Pipeline with nozzles were installed outside the building on the wall above the inlet openings. Cooling effect was evaluated by comparing the measured parameters of the microclimate in the section with cooling (C) and without cooling (N) and in the outdoor environment. Evaporative cooling system was activated since noon to 6.00 p.m. Measurements were carried out from 1.00 to 6.00 p.m. Universal device ALMEMO 2290-4 and anemometer Testo 435 were used for recording of measured parameters. Basic statistic parameters were calculated, data were analysed by One-Way AOV by the STATISTIX, version 9.0.

During the evaluated summer period (48 h), the outdoor air temperature ranged from 21.5 to 34.8°C and relative air humidity ranged from 32.2 to 84.2%. Indoor air temperature in the section N ranged from 23.4 to 33.3°C and in the section C from 24.0 to 31.1°C. The relative humidity ranged from 35.7 to 76.4% and from 56.0 to 74.4% in sections N and C. The temperatures 32°C and higher were registered only in the section without cooling. At an average outdoor air temperature 31.54°C (during the application of water spraying), the temperature of air in the section C (29.96°C) was lower by 2.92°C than in the section N (32.88°C, $P<0.001$) and lower by 1.58°C than the outdoor temperature ($P<0.001$). Relative air humidity in section C was higher by 18.52% than in section N (67.17% vs. 48.65%, $P<0.001$). The average air flow velocity in animal zone in section N was 0.113 m/s and in section C it was 0.175 m/s ($P>0.05$). The average outdoor wind speed was higher (1.226 m/s, $P<0.001$).

Efficiency of evaluated evaporative cooling system was moderate, because the nozzles were placed outdoors and only part of the humidified and cooled air was drawn into the building through inlet openings, and also because the indoor air flow velocity was low.

Key words

Summer period, cooling system, water evaporation, microclimatic parameters, sows.

Introduction

Pigs are relatively sensitive to high environmental temperatures when compared to other species of farm animals. A lot of research has been done on the factors affecting heat production in pigs (Brown-Brandl et al, 2001). Air temperature as cardinal environmental factor is influenced by relative humidity and air flow velocity. Optimum parameters of temperatures, relative humidity and air velocity for pigs in Slovakia presented Botto et al (2010). Recommended optimum of the air temperature for pregnant sows is 12-20°C at relative humidity 50-75%. Maximum air flow velocity at optimum temperature is 0.3 m/s and at higher temperature than optimum 2.0 m/s. Air humidity level is very important in cooling process.

Sows are exposed to heat stress when temperature exceeds the upper critical temperature of the thermoneutral zone of the sow (Black et al, 1993) and they will reduce both production and reproduction to control body temperature. Sows begin to feel the negative effects of heat stress at a temperature 20°C, and temperatures 26°C and higher are considered a critical for pigs (Christianson et al, 1982; Quiniou et al, 2001). Heat stress is one of the major concerns in pork production during summer period because pigs do not have functional sweat glands like other livestock species to assist them in efficiently removing body heat (Souza, 2009). Heat stress in pigs impairs the animals' welfare and environment (Huynh, 2005). The pigs would rid themselves of excess body heat by panting or surface wetting in water or their own excreta under the high ambient temperature and humidity (Huynh et al, 2006). High ambient temperatures cause heat stress and contribute to an increase in sow nonproductive days (St-Pierre et al, 2003). Exposing of sows to heat stress before mating and during early pregnancy may cause reduction in the conception rate and increase in the embryo mortality (Renaudeau et al, 2003), therefore negatively affecting subsequent reproductive performance (Suriyasomboon et al, 2006).

Utilization of enhanced air flow is one possible method of cooling during high ambient temperatures. In this system the sensational effect of temperature perception is applied. It means that at equal ambient temperature but higher air flow the ambient temperature is sensationally decreased. The cooling effect of air movement is typically expressed by effective temperature, the temperature that animals actually feel. Barbari and Conti (2009) found out that the high velocity air stream combined with wet floor was preferred by sows during the hottest period.

Evaporative cooling such as water dripping, showering system and evaporative pads are common and effective way in practice (Bull et al, 1997), but often limited to high relative humidity conditions with inducing additional water vapour into the animal occupied zone (Lucas et al, 2000). Water evaporation cause air-cooling in the building but at the same time, it causes an increase in humidity.

Material and methods

The objective of this work was to evaluate the effect of hot summer weather on microclimatic parameters in the stable for mated and pregnant sows without and with using of evaporative cooling.

The experiment was conducted in relatively hot summer

2012 (29-34°C) in the stable for mated and pregnant sows. Animals were housed in strawless gestation crates, which were arranged in 13 transverse rows with a total housing capacity of 120 sows. The housing also included 4 pens for boars, which were located in the alley next to the longitudinal peripheral wall oriented to the northwest. Feed was metered into a continuous trough, which also served for watering. Water level was maintained there by valve. Extract cross-ventilation was used in the house. Air was exhausted by 7 fans installed in the south-eastern outdoor wall with total capacity of 4000 m^3/h. Ten inlet flap-regulated openings, 2 x 600 x 200 mm each, were situated in the opposite wall of the building. Outside air cooled by sprayed water was drawn into the building, so indirect evaporative cooling process was used.

High-pressure water nozzles (11 units) provided spray. They were installed outside the building on a plastic pipe, located at the northwestern wall, at the end of the eaves, 650 mm above upper edge of the flap. Water jet sprayed out of nozzle by an angle of 45 ° downward.

During the experiment the air was cooled only in one half of the house (section C) and in the other one not modified air was exhausted (section N). Indirect evaporative cooling system was activated since noon to 6.00 p.m. Measurements were carried out from 1.00 to 6.00 p.m. Air temperature, relative humidity and air velocity were continuously recorded at 12 locations in each section in the zone of animals (500 mm above the floor) and at one place outdoor. Universal device ALMEMO 2290-4 and anemometer Testo 435 were used for recording of measured parameters.

Obtained microclimate parameters (temperature, relative humidity, air flow) were statistically processed and compared among the cooled (C), not cooled (N) sections and outdoor environment. Basic statistic parameters (mean values and standard deviations) were calculated, data were analysed by One-Way AOV, and significant differences were tested by Tukey HSD All-Pairwise Comparisons by the STATISTIX, version 9.0.

Results and discussion

During the evaluated summer period, the outdoor air temperature ranged from 21.5 to 34.8°C and relative air humidity ranged from 32.2 to 84.2% (Table 1). Air temperature in the stable for sows ranged from 23.4 to 33.3°C and the relative humidity ranged from 35.7 to 76.4%. In the section without activated evaporative cooling were registered the temperatures 32°C and higher, which represented the proportion 21.53 % of the whole observation time. Such values did not occur in the section with cooling.

When the outside air temperature was 31.54 ± 0.66°C, the indoor temperature in the section without cooling (N) was the highest 32.88 ± 0.71°C (Table 2). The temperature in the section with cooling (C) was the lowest 29.96 ± 0.77°C. Temperature in section C was lower by 2.92°C than in section N and lower by 1.58 °C than outdoor temperature. In section N, the temperature was higher by 1.34°C than the outdoor temperature. The differences in all cases were on a very high significant level ($P<0.001$, Table 3)

Relative air humidity in section C was higher by 18.52% than in section N and in comparison with the outdoor humidity it was higher by 21.85% (Table 2). Relative air humidity in section N was higher only by 2.80% compared with the outdoor air humidity. However, similar to temperature also in relative air humidity very high significant differences were recorded in all cases ($P<0.001$, Table 3).

The average air flow velocity in animal zone in section N was 0.113 ± 0.066 m/s, and in section C it was 0.175 ± 0.030 m/s (Table 2). The difference between the sections N and C was not significant (Table 3). The average outdoor wind speed (1.226 ± 0.919 m/s, $P<0.001$) was significantly higher compared to air flow in both sections.

According to Myer and Bucklin (2001), sows begin to feel the negative effects of heat stress at a temperature 20°C, and temperatures 26°C and higher are critical for them (Quiniou et al, 2001). All indoor air temperatures exceed 20°C, the upper value of the optimum. Average indoor relative humidity was in the optimum range recommended by Haeussermann et al (2007).

Huynh et al (2006) evaluated the combinations of two cooling systems (water bath and sprinkling) in pens with or without additional outdoor yards. They found out that the bath and sprinkling reduced respiration rate and their surface body temperature. Rectal temperature was not influenced by any treatment. A cooling system with sprinkling should avoid introducing surplus water into the air of barns. The main limitation of vapour cooling system is a heavy water use and an increasing of air humidity.

Evaluated system of indirect evaporative cooling is easier from service and economy view points, but it is not possible to achieve adequate results at cooling, as described Lucas et al (2000), without additional construction and technological arrangements.

In pig husbandry was developed a lot of technical solutions with direct and indirect elimination of heat stress of animal with different breeding effect and economy. Some cooling systems involve high investments and some can cause adverse effects like increased humidity. It is known that high relative humidity depresses pig production (Lucas et al, 2000). Silva et al (2009) found positive effects of sow cooling by using the floor cooling system. Although the results of this method of cooling are interesting in view of the breeding results, its implementation in existing pig husbandry is difficult.

Conclusion

The specificity of the evaluated indirect evaporative cooling is that this system uses outside air humidification before its inlet into the experimental stable for mated and pregnant sows. The resulting temperature difference with the application of cooling reached in our experiment cooling of the indoor air about 3°C. Partial increase of indoor relative humidity was within the range of recommended values. During the period with the higher relative humidity of ambient air, the air cooling system is not used. Running fans with higher output provided cooling at that time only by air flow. Due to low indoor air flow velocity (below 0.18 m/s), a change in apparent temperature was slight. It would be possible to provide markedly better effectiveness of indirect cooling by increasing the air velocity up to 2 m/s in the zone of animals and thus achieve better conditions for thermal comfort of housed sows. In capital-intensive cooling systems it is possible to achieve greater impact; however, usually they cannot be installed additionally in full operation on farm. Efficiency of evaluated evaporative cooling system was moderate, because the nozzles were placed outdoors and only part of the humidified and cooled air was drawn into the building through inlet openings, and secondly because the indoor air flow velocity was low.

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Table 1. *Temperature and relative humidity* during the evaluated summer period (48 h)

Measuring location	Temperature, °C			Relative humidity, %		
	$\bar{x}$ ± SD	Min	Max	$\bar{x}$ ± SD	Min	Max
Outdoor environment	27.28 ± 4.29	21.5	34.8	63.12 ± 16.03	32.2	84.2
Section N (without cooling)	27.91 ± 3.40	23.4	33.3	57.97 ± 12.33	35.7	76.4
Section C (with cooling)	27.36 ± 2.47	24.0	31.1	66.70 ± 5.92	56.0	74.4

Table 2. *Average values (± SD) of microclimate parameters in cooling time*

Measuring location	Temperature, °C	Relative humidity, %	Flow velocity, m/s
Outdoor environment	31.54 ± 1.20	45.85 ± 10.85	1.226 ± 0.919
Section N (without cooling)	32.88 ± 0.71	48.65 ± 5.10	0.113 ± 0.066
Section C (with cooling)	29.96 ± 0.77	67.17 ± 3.00	0.175 ± 0.030

Table 3. *Differences of microclimate parameters among outdoor and indoor environments*

Measuring location	Temperature, °C	Relative humidity, %	Flow velocity, m/s
Section N - Outdoor environment	1.34^{***}	2.80^{***}	-1.113^{***}
Section C - Outdoor environment	-1.58^{***}	21.32^{***}	-1.051^{***}
Section N - Section C	2.92^{***}	-18.52^{***}	-0.062^{NS}

*** Differences are significant on the level of P<0.001, ^{NS} Differences are not significant (P>0.05).