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Evaluation of an automated temperature control equipment for lactating sows

Renato Mattos Fernandes[1], Maria Luiza dos Santos Maciel[1], Alexandre Vinhas de Souza[2*], Leticia Gomes de Morais Amaral[3] and Nikolas de Oliveira Amaral[1]

[1]Departamento de Zootecnia, Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais, Machado, Minas Gerais, Brazil. [2]Departamento de Zootecnia, Universidade Federal de Lavras, Aquenta Sol, Cx. Postal 3037, 37200-900, Lavras, Minas Gerais, Brazil. [3]Departamento de Ciência e Tecnologia de Alimentos, Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais, Machado, Minas Gerais, Brazil. *Author for correspondence. E-mail: alexanndremb@hotmail.com

ABSTRACT. The present study aimed to develop and evaluate an automated cooling control system (ATCE) for sows in the farrowing phase. The experiment was conducted at the Swine Production Unit, Federal Institute of Education, Science and Technology, Campus Machado, Machado, state of Minas Gerais. Sixteen sows and their offspring were evaluated, eight treated and eight controls, in a randomized block design, with eight replications. Surface temperature, body temperature and respiratory rate of the animals were evaluated, in addition to floor temperature and performance parameters. The use of ATCE decreased the floor temperature (12h) and neck temperature (12 and 16h) ($p < 0.10$). In addition, there was a reduction in rectal temperature (12h) and respiratory rate (12 and 16h) in ATCE animals ($p < 0.10$). No significant differences were detected in the coefficient of variation (CV) of birth weight, but at weaning the CV of piglet weight was 26.3% lower in animals subjected to the ATCE ($p = 0.079$). Furthermore, the difference in CV between birth and weaning was also lower with the use of ATCE ($p = 0.015$). It can be concluded that the use of ATCE has a positive influence on the thermal comfort of females, in addition to improving litter uniformity.

Keywords: automation; welfare; technology; temperature; ventilation.

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Introduction

Heat stress remains one of the main challenges for swine production in tropical countries. Pigs, in particular, are very sensitive to high temperatures due to their low sweating ability and their fragile cardiovascular system (Chen et al., 2018). Pig facilities that provide temperatures between 18 and 25°C promote thermal comfort, but when exceeding 25°C, pigs initiate physiological and behavioral mechanisms for heat dissipation, directly affecting their performance (Amavizca-Nazar, Montalvo-Corral, González-Rios, & Pinelli-Saavedra, 2019).

Pregnant and lactating sows are even more affected by heat stress. Immediately under stress, sows decrease food intake as a mechanism to reduce heat production, in addition to producing less milk (Silva et al., 2009). Furthermore, sows outside their comfort zone have impaired reproductive performance, including a lower conception rate, longer time from weaning to the next estrus and increased stillbirth rate (Silva et al., 2009; Renaudeau, Noblet, & Dourmad, 2003; Renaudeau & Noblet, 2001).

Although temperatures of 29°C in farrowing are favorable for piglets (Ribeiro et al., 2018), sows are uncomfortable at temperatures above 22°C (Quiniou & Noblet, 1999). Temperature control measures in the farrowing environment are essential for good milk production by the dam and better litter performance. Therefore, the strategy of automating temperature control for lactating females is valid and has great potential for implementation.

The main means of cooling found on farms are cooling the entire shed or directly on the animal, by convection, conduction and evaporation (Parois et al., 2018). Generally, the drip and sprinkler system are the most used, but cooling with air directed at the animal head is also used. However, the animal production chain is undergoing several changes towards informatization and automation (Zhang, Zhang, & Liu, 2019). Today it is already possible to monitor changes in body temperature in pregnant sows in real time. This technology is usually performed by sensors placed in the sheds, and has a positive correlation with the sow's birth rate (Weihan, 2017). Nevertheless, information about automation in temperature control in farrowing sheds is limited.

By automating this process and using low-cost equipment, it is possible to minimize human error and ensure productive and reproductive indices related to animal welfare in terms of controlling ambient temperature. Thus, the objective of this study was to develop a prototype for temperature control and evaluate its effect on the reproductive and productive parameters of piglets and sows.

Material and methods

Animals

The experiment was conducted at the Swine Production Unit, Federal Institute of Education, Science and Technology, Campus Machado, with approval by the Animal Ethics Committee (CEUA) under protocol 21/2017.

Sixteen commercial lactating sows of high genetic value between the 1st and 7th order of farrowing and their litters until weaning (21 days) were used. Females were housed individually in cages with a partially slatted concrete floor (2.00 x 1.60 m) separated by non-communicating masonry walls. Each cage was equipped with a manual feeder and a nipple drinker for the females and an creep for heating the piglets. Soon after farrowing, litters were standardized to 10 piglets. Sows were weighed up to 24 hours after parturition and on the 21st day. All females, as soon as they arrived at the farrowing facility, had free access to water and received an amount of 2.6 kg feed per day until parturition. After farrowing, the diet was offered ad libitum, five times a day (7:00, 9:30, 12:00, 14:30 and 17:00 hours). All diets were formulated according to the recommendations proposed by Rostagno et al. (2011).

Automatic temperature control equipment

Automatic temperature control equipments (ATCE) were constructed. The ATCE was powered by a source of 12 volts and 5 amperes, composed of a digital thermostat, fixed to a 100mm Cap and connected to the central junction and with an external sensor, accurate to 1ºC; A timer is activated by the thermostat and activates the solenoid for a pre-set time of 15 seconds, a solenoid valve; after the solenoid, there is a fan-type sprinkler directed towards the animal back. Two CPU coolers were placed at the lateral TE junctions, which are thermostat-activated and the generated airflow is focused on the animal back (Figure 1).

The ATCE was installed alternately in farrowing cages on the animal back, directed to the sow head, influencing only the sows and not the cage microclimate. The devices were programmed to turn on when the ambient temperature reaches 22°C and turn off when it reaches 20°C. At that moment, a single spray of water occurs on the animal for 15 seconds.

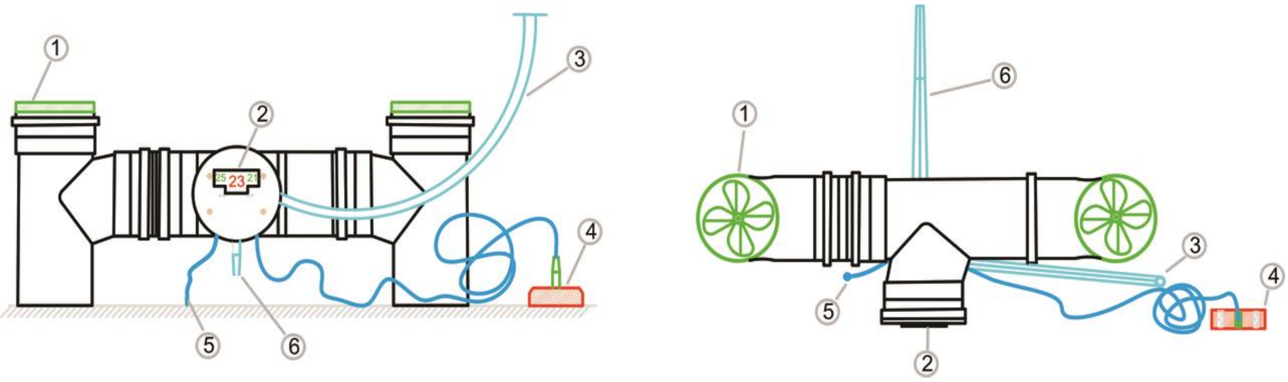

Figure 1. Image illustrating the fully assembled ATCE, connected to the hydraulic and electrical systems. 1) Cooler. 2) Digital thermostat. 3) Hose for water supply. 4) Power outlet. 5) External temperature sensor accurate to 1°C. 6) Fan sprinkler.

Experimental design

The 16 sows were divided into two groups and distributed in a randomized block design of two treatments: automated temperature control (n=8) and conventional temperature control model (n=8), each animal was considered an experimental unit. The criteria for forming the blocks were the farrowing order of the dam and the start time of the experiment.

Analyzed variables

After farrowing, piglets were identified and weighed up to 24 hours after birth and at weaning to assess weight gain. Piglets were subjected to the management of the farm, with teeth and tail cutting, weighing and identification up to 24 hours after birth; on the third day there was an application of 2 mL ferric hydroxide; on the seventh day, males were surgically castrated and on the tenth day, piglets started to receive feed at the farrowing pen to start food adaptation until the 21st day. Sows were weighed up to 24 hours after parturition and on the 21st day of lactation, piglets were weaned.

To determine the catabolic alteration, the equation proposed by Whittemore and Yang (1989) was used: catabolic alteration (kg) = 0.4146 x change in body weight (kg) -1.278. Pens were cleaned daily and leftovers were measured to determine intake.

The calculation of the estimated milk production of females was performed based on the equation proposed by Ferreira, Costa, Pereira, and Gomes (1988): milk production (kg day^{-1}) = [(4.27 x piglet weight gain in the period) x number of piglets] / number of days of lactation.

During the experimental period, three times a week at 12:00 and at 16:00 hours, rectal temperature was measured, as well as the respiratory rate of the sows, the surface temperatures of the animal (neck, leg and breast temperatures) and cage temperature. In the environment, floor temperature was measured immediately after the female got up. For this, an infrared laser thermomGM 320® was used. Temperature and humidity of the environment were also measured daily at 7:00, 9:30, 12:00, 14:30 and 17:00 hours and the humidity and maximum and minimum temperature were recorded by a Thermo hygrometer (Hikari HTH-240®).

Statistical analysis

Data were tested by analysis of variance after testing for normality, homoscedasticity of variance and independence of errors. For variables where data was not normally distributed, they were transformed using the SAS RANK procedure (SAS Inst. Inc., Cary, NC). The PROC RANK instruction with the NORMAL option was used to produce a normalized transformed variable. Variables were tested by analysis of variance by the PROC MIXED of SAS, and considered significant when $p < 0.10$ by F-test. Data were analyzed using the SAS 9.3 software.

Results

The maximum and minimum temperature were 29.16 and 20.20 °C, respectively. The relative humidity ranged from 55.7 to 76.9%. However, extreme temperatures ranging from 15.6 to 31.8 °C and humidity ranging from 36 to 90% were recorded.

The use of ATCE reduced the floor temperature of the cages by 0.84°C (p = 0.084; Table 1). The neck temperature of the sows, both at 12 and 16h, were also lower in animals subjected to cooling. Likewise, there was a significant reduction in rectal temperature of the sows at 12 hours (p < 0.010). Females subjected to ATCE had a decrease of 0.21°C in rectal temperature compared to the control (p = 0.050). In addition, there was a decrease in the respiratory rate of females subjected to ATCE, both at 12h (p = 0.003) and 16h (p = 0.028; Table 1).

Table 1. Temperature and respiratory rate of lactating sows subjected to an automated cooling system.

Variables		Treatments		SEM	p-value
		Control	ATCE		
Floor temperature 12h	°C	30.01	29.17	0.47	0.084*
Floor temperature 16h	°C	29.41	29.02	0.37	0.352
Neck temperature 12h	°C	36.60	35.00	0.38	0.006*
Neck temperature 16h	°C	36.81	35.80	0.37	0.019*
Chest temperature 12h	°C	37.77	37.64	0.21	0.674
Chest temperature 16h	°C	37.84	37.59	0.28	0.538
Leg temperature 12h	°C	36.87	36.64	0.36	0.261
Leg temperature 16h	°C	36.63	36.75	0.22	0.540
Rectal temperature 12h	°C	38.49	38.28	0.14	0.050*
Rectal temperature 16h	°C	38.73	38.57	0.13	0.102
Respiratory rate 12h	mpm	54.95	43.13	1.98	0.003*
Respiratory rate 16h	mpm	60.76	49.13	3.94	0.028*

*Significant (p < 0.10); SEM= Standard error of the mean; mpm: movements per minute.

No significant differences were detected in the performance parameters of sows and their litters (p > 0.10, Table 2). However, the coefficient of variation of piglets at weaning and the difference between the coefficients of variation at birth and at weaning were influenced by the ATCE (p = 0.079 and p = 0.015, respectively), demonstrating that the cooling system provided greater uniformity of piglets.

Table 2. Performance of sows and their respective litters subjected to an automated cooling system.

Variables		Treatments		SEM	p-value
		Control	ATCE		
Weight change	Kg	-4.96	2.21	5.20	0.326
Catabolic Alteration	Kg	0.78	-2.20	2.16	0.326
Milk production	Kg day^{-1}	9.46	10.03	0.41	0.358
Average daily intake	Kg	5.92	6.30	0.34	0.453
Weaning-to-estrus interval	Days	5.38	5.14	0.75	0.730
Initial litter weight	Kg	1.56	1.57	0.08	0.937
Final litter weight	Kg	6.32	6.54	0.28	0.483
Birth weight CV	%	15.54	15.60	3.18	0.975
Weaning weight CV	%	20.55	14.74	2.34	0.079*
Difference between CV**	%	4.56	-0.86	2.75	0.015*

*Significant (P<0.10); SEM= Standard error of the mean; CV: coefficient of variation. ** Difference in the CV between birth weight and weaning weight.

Discussion

The maximum and minimum temperatures found in the farrowing pen were 29.16 and 20.20°C, respectively. Considering the thermal comfort zone for lactating sows between 12 and 22ºC (Black, Mullan, Lorschy, & Giles, 1993), it is possible to infer that the sows were subjected to thermal stress. In tropical countries, such as Brazil, the temperature range during the year can be challenging for pig farmers. In 2017, in the region where the study was carried out, the average, maximum and minimum temperature were 20.55, 28.05, 14.65°C, respectively (Instituto Nacional de Meteorologia [INMET], 2017). Thus, pig farms that do not adopt cooling measures may have sow performance impaired by heat stress.

The use of ATCE decreased the floor temperature (p=0.084) of the cages, besides the respiratory rate and rectal temperature of the sows (Table 1). Floor cooling favors dissipation as sensible heat, due to the temperature gradient between the animal and the cooled floor (Van Wagenberg, Van der Peet-Schwering, Binnendijk, & Claessen, 2006). However, heat is also dissipated from the floor to the environment. In this sense, heat dissipation may have occurred mainly by evaporation. In addition, the lower respiratory rate observed in refrigerated females indicates the effectiveness of the equipment in improving animal welfare. It is known that the respiratory rate can be increased by heat stress since respiration in the swine species is a fundamental physiological mechanism in thermoregulation (Manno et al., 2006).

The surface temperature of the neck was higher in control animals. Under heat stress, animals use physiological and behavioral mechanisms to maintain homeothermy. One of these physiological mechanisms is peripheral vasodilation as a way of dissipating heat from the body (Ferreira, 2016), increasing surface temperature. On the other hand, sows subjected to ATCE had their neck surface temperature reduced at 12h, but not necessarily due to contact with the floor, since the other regions evaluated (chest and leg) had no significant decrease in surface temperature. As the equipment was installed directing the air current to the dorsal region of the animal, this may have helped to reduce the temperature of the neck. Another point is that as the animal behavior was not evaluated, it is not known whether neck temperature was lower because females were more active - standing, with more contact with the equipment and less in the supine position or actually because most of the time lying in contact with the refrigerated floor.

The coefficient of variation of piglets at weaning and the difference between the coefficients of variation at birth and at weaning were influenced by ATCE (p = 0.079 and p = 0.015, respectively), demonstrating that the cooling system resulted in greater uniformity of piglets (Table 2). These results are quite relevant, as homogeneous litters result in lower pre-weaning mortality and better performance in the following phases (Kyriazakis & Whittemore, 2006).

It is necessary to emphasize that studies involving sows and piglets require a very high number of animals to minimize the influence of several variables (order of farrowing, weight and backfat thickness of sows, health challenge, difficulties related to parturition, among others). Furthermore, the period in which the experiment was carried out, between March and May, does not reflect the period in which the highest average temperatures are recorded in the region of Machado, state of Minas Gerais. These factors may have contributed to minimizing the effects of ATCE.

Thus, the present study demonstrates the need to continue studies on ATCE, expanding the number of animals and the period of use throughout the year and, in addition, including physiological and behavioral parameters in the variables analyzed.

Conclusion

In conclusion, the use of ATCE improves the welfare of lactating sows by reducing the floor temperature of the farrowing facility, reducing surface and body temperature and decreasing the respiratory rate of females. In addition, the use of ATCE promotes more uniformity to the litter.

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