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SURFACE TEMPERATURE OF WARM-WATER PADS FOR HEATING PIGLETS IN FARROWING PENS

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ABSTRACT

The objective of this study was to evaluate the supplementary piglet heating on the basis of surface temperature of warm-water pads (WWP) in strawless farrowing house. Two WWPs (0.48 m^2) were installed in each farrowing pen for piglet heating. Surface temperature of all double-size pads was measured by infrared thermometer (GIM 3590) in 120 farrowing pens during winter season. Average surface temperature of the pads was assessed in 8 groups in section rows (in the order of 1st till the 8th pen) including frequency distribution of temperatures in the range 34 – 43 °C (with scale of 1 °C), in the range 37 – 43°C and 39 – 41°C, and in the 3 specific temperature limits (< 37.8 °C, 37.8 – 38.9 °C, and > 38.9 °C). The data were analyzed using the Descriptive Statistics procedure and a General Linear Model ANOVA by the statistical package STATISTIX 10.0. Significance of differences between WWP in pens was determined by LSD All-Pairwise Comparisons Test (at $\alpha \leq 0.01$). Outdoor average air temperature was -0.6 °C and average temperature in the farrowing sections was 18.7 °C during the measuring period. Warm-water pads in the group of second pens had the highest average surface temperature 40.59 ± 0.96 °C. The pads in the eighth group of pens had the lowest temperature 37.91 ± 1.83 °C ($P < 0.001$), because these were situated at the external enclosure wall of stable. In these pens, internal wall was not thermally insulated sidelong the heating pads, as it was in the first group of pens. As far as the average surface temperature is concerned, almost 94.17 % of double-size pads had advantageous temperature (37 – 43 °C) and 67.50 % had the optimum temperature (39 – 41 °C). It is possible to get improvement of temperature conditions by additional insulation of the external enclosure wall in the area of pens as well as by optimal heat regulation of the pads basec on the position of lying piglets.

Key words: warm-water pads; temperature; farrowing pen; piglets

INTRODUCTION

The newborn pig is extremely susceptible to cold, damp conditions. It has little fat and hair, a thin skin and a small mass in relation to its body surface area (Roese and Taylor, 2006). Pigs have a normal temperature range of 38 – 40 °C. Piglets do not have the ability of thermoregulation at birth, because they need heat immediately to survive and grow (Blecha, 2001). Immediately after birth, a piglet's temperature can drop by 1 °C or more within the first half-hour, depending on environmental conditions. Under favourable conditions, this decrease in temperature is regained in about 24 – 48 hours (Roese and Taylor, 2006).

This is particularly stressful for a newborn piglet which after birth experiences a sudden 15 – 20 °C decrease in ambient temperature (Herpin *et al.*, 2002). Piglet after its birth leaves a warm draft-free environment of 38.9 °C which is the sow's womb temperature and so for the newborn piglet even the temperature of 35 °C is cold during the first hours its life. At temperatures below 37.8 °C the piglet uses the sow milk also for warming its body (AHSI, 2010). For new born pigs in its resting (creep) area the temperature should be range from 32 °C (Lean, 1994; Curtis, 1995) to 35 °C (Xin and Zhang, 2000), which gradually decreases till 22 – 24 °C weaning (Herpin *et al.*, 2002; Ilsters *et al.*, 2009). When the temperature drops below the piglets'

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thermo-neutral zone (34 – 36 °C), piglets try to increase their heat production by means of energetically demanding muscular shivering thermogenesis (Berthon *et al.*, 1994), and they try to reduce their heat loss by social and individual thermoregulation (Vasdal *et al.*, 2009).

Recommended optimum range of the air temperature in farrowing house for lactating sows is 16 – 22 °C only (Odehnalova *et al.*, 2008; Pig Welfare Standards, 2012). The temperature of 22 °C is upper critical thermal limit for the lactating sow (Quiniou and Noblet, 1999). Because room temperature in the farrowing unit is usually kept within the sows' thermal comfort zone (around 20 °C), it is necessary to provide a suitable temperature (30 – 34 °C) in the creep area by external heat sources and some sort of insulated flooring to avoid hypothermia in piglets. Several studies have found that newborn piglets prefer to huddle near the sow and littermates despite unfavourable thermal conditions in the sow area, instead of staying in the heated creep area during the first days after birth (Andersen *et al.*, 2007; Vasdal *et al.*, 2009). Hypothermia might often predispose piglets to starvation and crushing by the sow (Edwards, 2002), especially in the first three days of life when crushing risk is at its greatest (Berg *et al.*, 2006).

Newborn piglets have remarkably higher requirements for warmth. Because the neonatal piglet requires quite a different environment from the sow, heated creep area (away from the sow) is essential in the farrowing pen (Roese and Taylor, 2006). It is necessary to use local heating of their area, the best by heated pads. To keep minimum ambient temperature of 20°C till piglets' age of 1 month it is necessary to use local heating of their area.

Electric or warm-water pads for bottom local heating are used. Warmth transmission to piglets occurs by their body contact with the surface of heated pad. The surface temperature of pad (mat) is usually preset to certain levels (commonly 30 – 40 °C) according to the age of piglets, room temperature, and management style (Zhang and Xin, 2000a). Ilsters *et al.* (2009) suggested that the temperature of the resting place for piglets comprising of concrete floor panels should range from 35 °C to 40 °C. Zhang and Xin (2000b) proposed an acceptable mat surface temperature of 34 – 43°C for creep heating and for surface heating of piglets. de Baey-Ernsten *et al.* (1995) suggested a tolerable surface temperature range of 37 – 43 °C. If the goal is to increase piglets' use of the creep area during the first critical days after farrowing, it seems important to increase the attractiveness of the area itself by using temperature gradients (Lynch, 1983; Barber and Bourne, 1987). Vasdal *et al*. (2010) showed that piglets had a significant preference for 42 °C compared to 34 °C (P < 0.05) when different types of infrared temperatures in the creep area at 24 hours of age were tested.

Recommended surface temperature of WWP at the birth of piglets is about 38 – 41 °C (MIK International, 2014). The laying position of the litter determines the WWP temperature's control variable. Since the temperature needs of the litter cannot be established according to age, the lying position of the litter must be observed and the temperature adjusted as needed. According to DLG Fokus Test warm-water pads are tested from the point of view of the surface share with advantageous temperatures in the range of 37 – 43 °C and with optimum temperatures ranging from 39 °C to 41 °C (MIK International, 2009). From the viewpoint of comfort zone for piglets (AHSI, 2010), correct regulation of temperature, either optimum or advantageous surface temperatures of heated pads are important factors. The control of the surface temperature of heating areas is very important to keep the optimal temperature for the sucking piglets.

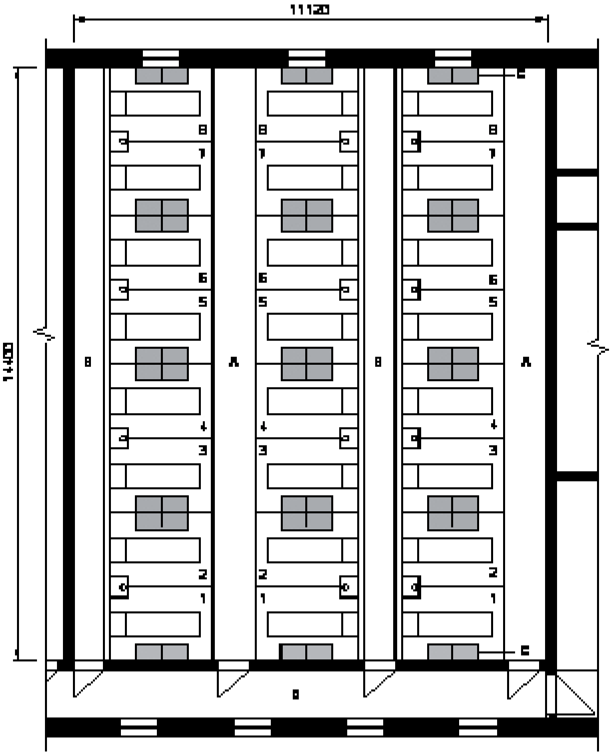

Fig. 1: Layout of the 1st farrowing section (from the total number of 5) with 3 x 8 farrowing pens with crate and warm-water pads for floor heating of piglets

1 to 8 - farrowing pens (pen groups according to their order), A - manipulating alley, B - feeding alley, C - warm-water pads, D - marginal lengthwise passage in stable

MATERIAL AND METHODS

The objective of this study was to evaluate the supplementary piglet heating on the basis of surface temperature of warm-water pads (WWP) in strawless farrowing house. In the farrowing house there were 5 sections with 3 rows of pens, 2 feeding and 2 manipulating alleys (Figure 1). In each row there was 8 farrowing pens with crate and a plastic slotted floor. The pens were situated across the alley in sections. Vacuum ventilation was regulated in all the sections.

The system of warm-water pads was used for supplementary heating of piglets. Two WWP with dimensions 400 x 600 mm were installed in each farrowing pen at the left or right side. They were mounted to the floor pen next to each other so as to create a long strip of 1 200 mm with a total area of 0.48 m^2 (double-size pad). Piglets had tipping covers at their disposal with plastic sheets. Warm-water pads in first farrowing pens were situated at the enclosure wall adjacent to marginal lengthwise passage of the farrowing unit. WWPs in the last group of (eighth) pens were situated in section rows at the external enclosure wall of the stable.

Surface temperature of double-size warm-water pad was measured in all the 120 farrowing pens by infrared thermometer GIM 3590 with an internal data logger (Greisinger Electronic GmbH, Regenstauf, Germany; accuracy ± 0.75 °C or ± 0.75 %, whichever was greater) in winter season. The measurements were taken vertically from a distance of 500 mm above the WWP surface as a whole by continuous scanning line in 4 selected longitudinal lines for a period of time about 11 seconds. Response time of this device was 150 ms, which correspond to a data set with about 70 values. Measured values of data sets (Max, Min, Avg) were continuous stored in device memory as the measurement protocols. Maximum, minimum and average values were related to the duration of measurement.

For data evaluation of 120 double-size pads farrowing pens were divided according to their order in the lateral section rows into eight longitudinal groups with 15 pens in each group. The average surface temperature of double-size pads was assessed in first to the eighth group of pens in the farrowing house including frequency distribution of temperature. Frequency distribution of surface temperature of WWPs was evaluated in the range 34 – 43 °C with scale of 1 °C (8 temperature zones with difference of 9 °C), than in the range from 37 °C to 43 °C and from 39 °C to 41 °C (as advantageous and optimum temperatures; MIK International, 2009) and in the three specific temperature limits (< 37.8 °C, 37.8 – 38.9 °C, and > 38.9 °C).

Temperature and the relative humidity of air were registered in the farrowing sections and in the external environment during the measuring period by electronic data loggers HDL (HIVUS Ltd., Žilina, Slovakia).

The data were analyzed using the Descriptive Statistics procedure and a General Linear Model ANOVA by the statistical package STATISTIX 10.0 was used (Analytical Software, Tallahassee, Florida, USA). Significance of differences between the average surface temperatures of warm-water pads in pens was determined by LSD All-Pairwise Comparisons Test (at $\alpha \leq 0.001$).

RESULTS AND DISCUSSION

Average temperature of air in the farrowing house was 18.7 ± 0.62 °C during the measuring period and average air temperature in the external environment was -0.6 ± 3.72 °C (Table 1). Indoor air temperature ranged from 17.4 °C to 20.6 °C and the outdoor air temperature ranged from -7.9 °C to 4.8 °C. Average relative humidity of air in the farrowing house was 54.6 ± 3.72 % and in external environment it was 73.8 ± 9.88 %. The indoor relative humidity of air ranged from 39.8 % to 64.6 % and the outdoor air relative humidity ranged from 49.1 % to 91.9 %. All the measured internal temperatures of air were suitable for sows (Odehnalova *et al.*, 2008; Pig Welfare Standards, 2012) but not for sucking piglets. Registered room temperatures were lower than 22 °C which is the bottom temperature limit for piglets in the time of their weaning (Herpin *et al.*, 2002) and supplementary heating by WWPs was essential to maintain the optimal temperature for the sucking piglets (Zhang and Xin, 2000;

Table 1: Temperature and relative humidity of air during the measuring period

Parameter	Air temperature, °C		Relative humidity of air, %	
	Farrowing house	External environment	Farrowing house	External environment
Average	18.7	-0.6	54.6	73.8
SD	0.62	3.72	4.67	9.88
Minimum	17.4	-7.9	39.8	49.1
Maximum	20.6	4.8	64.6	91.9

Table 2: Surface temperatures of double-size warm-water pads in farrowing pens according to their order in section rows (pen groups)

Parameter	Order of pens in a row in sections (pen groups in farrowing house)							
	1st	2nd	3rd	4th	5th	6th	7th	8th
Average*	40.20a	40.59a	40.27a	40.25a	40.26a	39.97a	39.30ab	37.91b
SD	1.29	0.96	1.08	1.19	0.55	0.72	1.27	1.83
Minimum	36.8	38.5	38.8	38.7	38.9	38.8	35.9	35.3
Maximum	41.9	42.1	42.0	42.7	41.0	40.8	40.7	40.5

*Significance of differences at P < 0.001, a-bData with an equal superscript are not significantly different from one another (LSD test at α = 0.001), n = 15 data sets (i.e. data set includes about 70 measured values)

Roese and Taylor, 2006; Vasdal *et al*., 2010).

Warm-water pads in the group of second pens in the farrowing house had the highest average surface temperature of 40.59 ± 0.96 °C (Table 2). The lowest temperature of 37.91 ± 1.83 °C (P < 0.001) was recorded for the pads in the group of eighth pens (last group of pens in section rows), which were situated at external enclosure wall. The internal wall in the area of these pens was not thermally insulated (by plastic plate) as most of the first group of pens (80 %). Warm-water pads in the group of the first group of pens, which were situated closest to the regulation unit, had average surface temperature of 40.20 ± 1.29 °C, i.e. by 0.39 °C lower than WWPs in the group of second pens in farrowing unit. However, this difference was non-significant statistically. Most likely it could be affected by the fact that the pads in the group of first pens were situated at the enclosure wall adjacent to marginal lengthwise passage in farrowing house. In this passage the temperature of air was lower than in the individual sections. Each of farrowing sections had four doors which were not always closed when the attendant staff was entering or exiting. The side pen walls in all the outlaying first pens in section rows (in the area with heating pads) were made from the ceramic tiles, but three farrowing pens in the middle section in this area did not have insulated wall in the form of plastic plate (like all the pens in the eighth in section rows). The surface temperature of ceramic tiles was lower than the surface temperature of the plastic plate. All mentioned factors could also affect the surface temperature of WWPs in the group of first farrowing pens.

Frequency distribution of 120 average surface temperatures of double-side pads (Table 3) indicated that the largest share of pad temperatures were in the range of 40 – 41 °C (40.8 %) and in the range of 39 – 40 °C (26.7 %). Ten pads (8.3 %) had surface temperatures lower than 38 °C and 16 pads (13.4 %) had surface temperatures higher than 41 °C. All measured surface temperatures were higher than 35 °C and lower than 43 °C, which corresponds with acceptable mat surface temperature range (34 – 43 °C) for creep heating as proposed by Zhang and Xin (2000b). Surface temperatures in the range of 37 – 43 °C, i.e. advantageous temperature (MIK International, 2009) were recorded for 113 double-size pads (94.17 %). This corresponds with a tolerable surface temperature range for surface heating of piglets as suggested by de Baey-Ernsten *et al.* (1995). Surface temperatures of 81 double-size pads (67.50 %) were in the range of 39 – 41 °C, which was also deemed as optimum temperatures by us (MIK International, 2009).

Frequency distribution of surface temperatures according to specific temperature limits (Table 4) suggested that 10 % of double-size warm-water pads had average surface temperature below 37.8 °C and 13 % of pads had the surface temperature between 38.7 °C and 38.9 °C. This means that the pads with temperature

Table 3: Frequency distribution of average surface temperatures of double-size warm-water pads in the farrowing house

Parameter	Range of surface temperatures in °C							
	35-36*	36-37	37-38	38-39	39-40	40-41	41-42	42-43
Number	4	3	3	13	32	49	11	5
%	3.3	2.5	2.5	10.8	26.7	40.8	9.2	4.2

*The lower limit of range includes the value and the upper limit excludes the value.

Table 4: Specific frequency distribution of average surface temperatures of double-size warm-water pads

Parameter	Specific range of surface temperatures in °C		
	< 37.8 °C[1)]	37.8 °C[2)] – 38.9 °C[3)]	> 38.9 °C
Number of values	10	13	97
Percentage share	8.33	10.83	80.84

[1)] the temperatures at which milk can be used for the heating of piglet body and not to growth, [2)] the temperature providing comfort zone for piglets, [3)] the temperature of the environment in the sow's womb

below 37.8 °C do not provide the comfort zone for piglets and a certain amount of milk received can be used for the heating of their body and not to growth (AHSI, 2010). Surface temperature of 38.7 °C or more may provide comfort zone for piglets and the value of 38.9 °C is the temperature of environment in the sow's womb. The largest share (97 %) of all 120 double-size pads had the surface temperature above 38.9 °C, which is favourable in terms of providing temperature comfortable for piglets during the first critical days after farrowing.

CONCLUSION

Among 8 groups of 15 double-size warm-water pads (total 120 pads with dimensions 400 x 1200 mm) the lowest average surface temperature (37.9 °C) was recorded in pads in the group of eighth (last) farrowing pens in section rows (by their order), which were situated at external enclosure wall without thermal insulation of side pen wall from ceramic tiles in the area with local floor heating. All the measured surface temperatures were higher than 35 °C and lower than 43 °C. As far as the average surface temperature is concerned, almost 94.2 % of double-size warm-water pads had advantageous (acceptable) temperature in the range of 37 – 43 °C and 67.5 % of double-size pads had the optimum temperature in the range of 39 – 41 °C.

It is possible to get improvement of temperature conditions by additional insulation of the external enclosure wall in the area of pens as well as by optimal heat regulation of water heated pads based on the position of lying piglets.

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