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Thermal comfort of pigs housed in different installations

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Abstract. In an intensive production system, the environment directly influences the comfort and welfare of pigs. Animals under heat stress may exhibit behavioural changes and changes in physiological parameters, such as increased body temperature, respiratory and cardiac movements. The aim of this study was to evaluate the thermal comfort of growing and finishing pigs housed in facilities with different construction typologies. The evaluated pens were: pen with water depth (WDP) and pen with partially slatted floor (SLF). Data on the ambient thermal environment in the pens and in the outside were collected automatically using Hobo dataloggers, model U12-013. This equipment recorded the air temperature, relative humidity of the air and black globe temperature in intervals of five minutes. Subsequently the variables were used in the calculation of the temperature index of the globe and humidity. The physiological responses of the animals were collected: Surface Temperature (ST) and Respiratory Rate (RF). When analyzing the parameters: ST and RF, it was observed that the WDP pen presented a significant difference in all the observed hours, with an increase observed throughout the day, and the SLF pen presented a difference at 9:00 a.m. presenting a lower value than the other schedules evaluated. The BGHI inside the pens showed average values in the hottest period of the day slightly above what is recommended for adult pigs. Both facilities during the hottest time of the day demonstrated a similar trend in relation to the evaluated variables, so it was concluded that both pens provided the same conditions of thermal comfort for the animals.

Key words: rural buildings, pigs, house design.

INTRODUCTION

Brazilian pig farms have the challenge of providing environmental comfort to the animals, aiming at the productive benefits (Morales, 2010). The environment has great influence on the welfare of the pigs (Machado Filho, 2000), an improper environment causes discomfort to the animals. The low level of animal welfare can affect production, reproduction, health and quality of the final product.

Ambience is the science that analyzes the characteristics of the environment as a function of the thermal comfort zone of the species, associated with physiological characteristics that regulate the internal temperature of the animal (Bridi, 2006).

The knowledge and identification of climatic variables that directly influence the performance of the animal in the form of thermal stress are the main measures to seek out and execute mitigating measures of discomfort and loss of production (Bloemhof et al., 2008; Nazareno et al., 2012).

Pigs grow and function better under thermoneutral temperature conditions. Pigs exposed to temperatures outside the thermoneutral zone may have behavioral and physiological changes, consequently reducing weight gain (Kiefer et al., 2010). Studies by MacLean (1969) found that in a situation of thermal stress, the immune system of the animals becomes weak, resulting in an inefficiency to resistance to infections.

The objective of this study was to evaluate the thermal comfort of growing and finishing pigs in facilities with different types of floors.

MATERIALS AND METHODS

The study was carried out in a commercial swine farm (Granja Niteroi) (21° 11' 37" S; 45° 02' 49'' W; 918 m) in the municipality of Lavras-MG, Brazil, from July to August 2014.

The climate of the region, according to Köppen's classification, is Cwa, i.e., rainy temperate (mesothermal) with dry winter and rainy summer, subtropical.

The evaluated housing system was intensive confinement, in which the animals do not have access to the outside of the facilities. The thermal environment and air quality of facilities with swine in growing and finishing stages were evaluated.

The animals were housed in pens as follows: with mean weight of 28.69 kg (pen with water depth, WDP); and with 28.5 kg (pen with partially slatted floor, SLF). The animals remained in the pens during the growing and finishing stages, reaching final mean weights of 83.47 kg (WDP pen) and 87.67 kg (SLF pen).

The animals were housed in masonry buildings covered with fiber-cement roofing, supporting structures in reinforced concrete, concrete floor and East-West orientation. Each pen was equipped with two automatic feeders and four nipple drinkers, with total area of 72 m² (8 x 9 m), ceiling height of 3 m, containing 72 animals each. The WDP pen had, on one of its sides, a lowering in the concrete floor (1 m wide and 10 cm deep), filled with water, and was fenced by masonry dividers with ceramic bricks covered with a layer of concrete render and painted in white. The SLF pen had dividers made of steel wire ropes, ceiling height of 3 m and concrete floor, with sides made of slotted precast concrete plates.

The surface temperature of the animals was determined in three times (09:00 a.m, 12:00 a.m and 03:00 p.m) with a surface thermometer, non-contact, infrared, Fluke 62 Mini model brand, with accuracy of ± 1% of reading. Five animals were chosen at random in each pen, where surface temperatures were collected. The temperature was collected at three points (back of neck, palette and ham), by calculating the average of the same, as performed by Amaral et al. (2014). These measures were performed during 40 days, within a two month interval.

For the collection of respiratory frequency was adopted methodology used by Amaral et al. (2014), where is made the measurement and counting of the movements of the animal for 15 seconds, later by multiplying by four to get the amount of movement per minute. Five randomly selected animals were observed in controlled trials (in each pen) during the hours of 09:00 a.m., 12:00 p.m. and 03:00 p.m., during the days of data collection. These measures were performed during 25 days, within a two month interval.

Data relative to the ambient thermal comfort in the pens and outside were automatically collected using data loggers (Hobo, model U12-013), with accuracy of ± 0.5° C. These devices recorded the dry bulb temperature, relative air humidity and black globe temperature in intervals of five minutes. To obtain the black globe temperatures (Tbg), the external sensors of the data loggers, inserted in black balloons, were used. The data loggers were positioned inside the facilities at a height of 1.20 m from the floor, as described in Sampaio et al (2004).

Based on the Tdb (bulb temperature), RH (relative air humidity) and Tbg values, the temperature and humidity index (THI), and the black globe temperature and humidity index were determined (BGHI). The BGHI, THI, and h were used to evaluate the thermal environment. Based on the BGHI, the effects of air velocity and radiation can be quantified indirectly.

The THI index was calculated using the equation proposed by Thom (1958):

$$THI = Tdb + 0.36\ Tdp + 41.2$$

where Tdb = dry bulb temperature (°C) and Tdp = dew point temperature (°C).

The BGHI index was calculated using the equation proposed by Buffington et al. (1981):

$$BGHI = Tbg + 0.36\ Tdp - 330.08,$$

where Tbg = black globe temperature (K) and Tdp = dew point temperature (K).

The thermal environment data (THI, BGHI, Tdb and RH) and the physiological variables (RF and ST) were subjected to analysis of variance using the "F" test and the means subsequently compared by the Scott knott test at 5% of significance. The analysis was conducted adopting a completely randomized design. The results were obtained with the aid of statistical software SISVAR 5.3.

RESULTS AND DISCUSSION

It was observed a significant difference for the variable Tdb between the pens and between the schedules, and the SLF pen presented mean values higher for 9:00 a.m. and 12:00 a.m. than in the WDP pen ($P < 0.05$, Scott-Knott test). The WDP pen presented a significant difference in all the observed hours, with an increase observed throughout the day, and the SLF pen presented a difference at 9:00 a.m, presenting a lower value than the other schedules evaluated (Table 1).

Sampaio et al. (2004) limit the thermoneutral zone between 15 and 21 °C. However, for pigs in the growing phase the values are: 18 °C to 25 °C, and 15 °C as critical cold limit and 26 °C as the critical heat limit. The average temperature values observed in the present study, in the afternoon, are a little above the range cited by Agroceres Pic (2008).

When pigs are exposed to high temperatures, performance is affected (Kiefer et al., 2010), mainly by reducing food intake and energy expenditure associated with thermoregulation processes (Manno et al., 2006).

Table 1. Mean values of environmental variables observed during the evaluated period, along the day, in swine growing and finishing facilities with floor with water depth (WDP), and pen with slatted floor (SLF)

Pens	Tdb (°C)			RH (%)		
	9:00 a.m.	12:00 p.m.	03:00 p.m.	9:00 a.m.	12:00 p.m.	03:00 p.m.
WDP	19.0aA*	25.8aB	26.9aC	73.9aA	49.8aB	45.2aC
SLF	22.8bA	26.6bB	27.1aB	57.9bA	44.96bB	40.6bC

Dry bulb temperature (Tdb); Relative air humidity (RH). *Averages followed by the same letter, lowercase in the column and uppercase in the row, do not differ by the Scott-Knott test at 5% probability.

The average RH showed a significant difference between the pens ($P < 0.05$, Scott-Knott test) and the pen with a water depth had the highest average values during the analyzed times, which was already expected due to the microclimate inside the pen created by the evaporation of the water present in the water depth.

According to Muller (1989), for pigs weighing over 30 kg and in thermal comfort, the optimal RH is between 50 and 70%. It was observed that in the evaluation of 9:00 a.m. the average RH in SLF pen was within the range quoted by Muller, however in the times of 12:00 p.m. and 03:00 p.m. it was below the value recommended by the author. The WDP pen presented a higher RH compared to the SLF pen at all evaluated times.

There were no significant differences between the pens for the THI and BGHI indices, but a significant difference was observed between the hours for each pen, the evaluation at 9 a.m. recorded lower values than for the other times in both pens for THI and BGHI (Table 2).

Table 2. Mean values of environmental indices observed during the evaluated period, in swine growing and finishing facilities with floor with water depth (WDP), and pen with slatted floor (SLF)

Pens	THI			BGHI		
	9:00 a.m.	12:00 p.m.	03:00 p.m.	9:00 a.m.	12:00 p.m.	03:00 p.m.
WDP	65.3aA	72.2aB	73.1aB	68.4aA	73.1aB	73.6aB
SLF	69.0aA	72.7aB	72.8aB	69.4aA	74.5aB	73.8aB

Temperature and humidity index (THI), Black globe-humidity index (BGHI); *Averages followed by the same letter, lowercase in the column and uppercase in the row, do not differ by the Scott-Knott test at 5% probability.

Turco et al. (1998) found that the BGHI upper limit of thermal comfort for adult pigs was 72. In the present study, although there were no statistical differences between the two facilities, at 12:00 and 03:00 p.m. mean values were above that recommended by Turco et al. (1998).

The THI values followed the same trend as the BGHI values, increasing due to the increase in Tbd, but values were below the values mentioned by Chase (2006) and Botto et al. (2014), who consider that THI below 74 is normal for pigs.

There was a significant difference in respiratory frequency, between the pens, as well as between times, between pens the difference occurred at the 9 o'clock time (Table 3), the animals housed in the WDP pen presented lower RF in comparison to the housed animals in the SLF pen, this was possibly due to the influence of the environmental variables (Tdb, RH). Both facilities presented significant differences between the schedules, the movements per minute increased in the higher temperature schedules (12:00 p.m. and 03:00 p.m.).

Table 3. Mean physiological variables observed in animals in the growth and termination phase confined in a water depth pen (WDP), and pen with slatted floor (SLF)

Pens	RF (mov.min^{-1})			ST (°C)		
	9:00 a.m.	12:00 p.m.	03:00 p.m.	9:00 a.m.	12:00 p.m.	03:00 p.m.
WDP	40.0aA*	48.8aB	54.0aC	31.5aA	33.4aB	33.7aB
SLF	48.0bA	51.6aB	59.2aC	32.9bA	33.7aB	34.0aB

RF: Respiratory Rate; ST: Surface Temperature. *Averages followed by the same letter, lowercase in the column and uppercase in the row, do not differ by the Scott-Knott test at 5% probability.

According to Hannas (1999), the first response of the pigs when exposed to the temperature above the upper limit of the thermal comfort zone is the increase of the respiratory rate, due to the direct stimulation of the hypothalamic center.

According to Ferreira (2011) the RF of adult pigs in comfort is 44 ± 7.9 movements per minute, the values found in the present study are within the range quoted only in the time of 9:00 am for both pens and at 12:00 p.m. for the WDP pen. According to Kiefer et al. (2009) the respiratory rate of pigs in the growth and finishing phase in comfort (21 °C) is 45.90 mov min^{-1}. However, Manno et al. (2006) found 48 ± 8 mov min^{-1} for swine (30 to 60 kg) maintained in thermal comfort. Correlation of RF and BGHI, it is possible to observe that the increase of BGHI influenced RF. High environmental temperatures may increase respiratory rate (Manno et al., 2006), the RF is one of the mechanisms for body heat loss, thus allowing the maintenance of homeostasis (Christon, 1988).

The ST also presented significant difference between the pens at the 9 o'clock time. It was also observed a difference between the schedules for both pens, the average surface temperatures at 12:00 p.m. and 3:00 p.m. were higher than at 9:00 a.m.

The ST values found in the present study are below those observed by Kiefer et al. (2010), which was 36.24 °C for swine in thermal comfort (21 °C). However, the values found are close to those obtained in the afternoon by Santos et al. (2018) when studying different environments. The variation of the surface temperature is high and may vary, among others, depending on the breeding system (Nazareno et al., 2012), race, environmental factors, metabolism adjustments, with the purpose of dissipating heat (Soerensen & Pedersen, 2015).

CONCLUSIONS

The BGHI inside the pens showed average values in the hottest period of the day slightly above what is recommended for adult pigs.

Both facilities during the hottest times of the day demonstrated a similar trend in relation to the evaluated variables, so it was concluded that both pens provided the same conditions of thermal comfort for the animals.

It recommends, that new studies should be carried out in the warmer period (summer season) to analyze the comfort of these animals.

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