NOCTURNAL THERMAL COMFORT IN FACILITIES FOR GROWING SWINES

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ABSTRACT: In most of Brazilian pig farms, the environmental acclimatization systems run manually. For night and early morning periods, this practice isn't appropriate, because, in general, there are not employees available to run these manual systems. This research aimed to compare the bioclimatic profile of two differently constructed facilities to the external environment, considering the period from 6 p.m. to 6 a.m. during the spring, in order to show that night and early morning temperatures do not coincides with growing pig's thermoneutral zone. For this reason, acclimatization must be also carried out at these periods. It was analyzed the dry bulb temperature, relative air humidity, temperature-humidity index (THI) and enthalpy data of the sheds and external areas. Under the studied conditions, it was possible to conclude that the constructively appropriate shed appeared to be less influenced by the external environment, allowing better thermal control for growing pigs. Further research must be conducted to verify if automatic cooling systems is needed during night and early morning.

KEYWORDS: thermal environment, animal welfare, pig farming, acclimatization system.

CONFORTO TÉRMICO NOTURNO EM INSTALAÇÕES PARA SUÍNOS EM CRESCIMENTO

RESUMO: Em grande parte das granjas de suínos no Brasil, os sistemas para climatização do ambiente funcionam com acionamento manual. Para os períodos matutino e noturno, esta prática não é adequada, uma vez que, nestes períodos, em geral, não há funcionários disponíveis para o acionamento destes sistemas. Por meio deste trabalho, objetivou-se comparar o perfil bioclimático de duas instalações construtivamente diferentes entre si e com o ambiente externo, considerando o período de 18 às 6h, durante a primavera, a fim de verificar que as condições de conforto térmico da noite e da madrugada podem apresentar-se fora do desejado para suínos em crescimento, e que, por esta razão, a climatização deve ser realizada também nestes períodos. Foram analisados a temperatura de bulbo seco, a umidade relativa do ar, o Índice de Temperatura e Umidade e a entalpia nos galpões e no ambiente externo às instalações. Nas condições estudadas, foi possível concluir que o galpão construtivamente adequado estudado mostrou ser menos influenciado pelo ambiente externo, propiciando conforto térmico mais adequado para os suínos em crescimento. Mais estudos devem ser realizados para que se verifique a necessidade de acionamento automático de equipamentos de climatização durante a noite e a madrugada.

PALAVRAS-CHAVE: ambiente térmico, bem-estar animal, suinocultura, sistema de climatização.

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INTRODUCTION

The welfare of pigs is influenced by climate variability, whose amplitude at certain seasons of the year exceeds the limits of comfort conditions of the animal.

The thermal environment influences important husbandry characteristics, such as ration intake, feed conversion ratio and weight gain of pigs (FAGUNDES et al., 2009, CHOI et al., 2011). KIEFER et al. (2010), studying barrows in termination subjected to high temperatures (32ºC), found a reduction in ration intake, weight gain and worsening in feed conversion ratio. MANNO et al. (2006) and BRÊTAS et al (2011) ratified the negative influence of the warm weather on the performance of the pigs.

According to FIALHO et al. (2001), in a tropical country where high temperatures occur during almost all the year, grower and finisher pigs are more exposed to and damaged by thermal stress. These authors attribute the decrease in performance at higher temperatures to the decrease in ration intake and energy cost associated with heat dissipation. They still states that the modern swine, improved to high deposition rate of lean meat, is the most affected by the heat stress.

Thus, in a country with a tropical climate, there is a need of acclimatization to cool the environment (NÄÄS, 2000). Despite the large amount of studies on this subject, there is still much negligence regarding the importance of maintaining the thermal comfort.

In most pig production units in Brazil, the acclimatization systems for cooling, if any, run with manual triggering, with or without the aid of instruments for measuring the temperature. This handling triggering often does not consider that periods of night and morning may also have temperatures above the thermal comfort zone of the animals.

Through this study, it was aimed to compare the bioclimatic profile of two constructively different pigs facilities and to the thermal environment in order to establish that the conditions for thermal comfort in the night and the morning may be presented out of the desired for growing pigs, therefore, the acclimatization is also necessary at these times.

MATERIAL AND METHODS

The experiment was conducted on a pig farm in the city of Boituva, in the state of São Paulo (SP), in Brazil. The farm is 547m above the sea level, at latitude 23°16'27,24"S and longitude 47°43'45,81"W. The annual temperature average in the region is about 21ºC, reaching a maximum of 32ºC in January and a minimum of 9°C in June, with frequent rain in summer. It has confined intensive farming, full-cycle farming and weekly organization of production.

The bioclimatic behavior of the two different sheds was studied from September 20th to October 14th, 2004. The facilities were built in the east-west direction, in order to promote a lower incidence of solar radiation inside the buildings due to the warm climate of the region. Each shed hosts 1.600 pigs of genetic lineages from the company AGROCERES-PIC in growth phase with body weight between 30 and 60kg (from 70 to 100 days of age). The studied treatments were:

Facility A - Roof composed of asbestos cement tiles, with average ceiling height of 2.4m. The roof area does not cover the entire shed, allowing more solar incidence during the day inside the shed. This shed was characterized as constructively inappropriate for the climatic conditions of the location.

Facility B - Roof composed of clay tiles, with average ceiling height of 3.2m. The roof area covers the entire shed preventing the solar incidence inside, except a small incidence during the winter. This shed was characterized as constructively appropriate.

The sheds were 18m wide and 150m long (Figure 1). Each shed had five rooms separated by masonry walls. Each room had 18m wide by 30m long and hosted 400 animals, and one room was always in fallowing. The animals were hosted in 10 pens with 40 animals each. These pens were separated by low masonry walls with 0.7m high. The sheds had no effective air-conditioning systems.

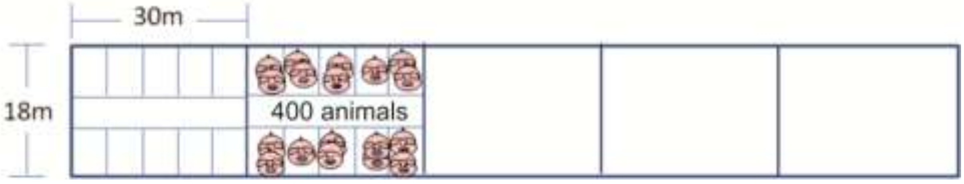

FIGURE 1. Schematic representation of the studied sheds.

It was collected and analyzed the dry bulb temperature and relative air humidity inside each room and in the facilities external environment from 6 p.m. to 6 a.m. To measure these variables it was used sensors (RHT - NOVUS) with accuracy of +3% for the relative air humidity and of +1°C to room temperature). The temperature and humidity sensors were connected to a datalogger to continuously record and store data (Field Logger - NOVUS). It was allocated 1.5m from the floor, inside one of the central pens, randomly chosen in each room. Through this system, data was obtained every 15 minutes. These data was organized by the supervision software (Field Chart - NOVUS).

To calculate the thermal comfort of the animals, it was used the THI (SARUBBI et al., 2010). Its most known type and the one used in this work is given by $THI = Tbs + 0{,}36To + 41{,}2$ (Eq. 1), where: THI = Temperature–Humidity Index, Tbs = dry bulb thermometer temperature, °C, To = temperature of the dew point, °C.

This equation was used by several authors, such as PERISSINOTO et al (2009), SOUZA et al (2010), SAMPAIO et al (2011).

For the appropriate THI calculus, for this animal category, the maximum and minimum room temperature values of the thermal comfort zone, as well as the critical values for heat and cold, in the manual of the genetics of pigs (AGROCERES PIC, 2008) hosted in the sheds, were used in the equation. This manual provides the following values for pigs in the growing phase: 18°C to 25ºC as optimum temperature, 15ºC as critical cold limit and 26°C as the critical heat limit. The relative air humidity data used were 50-70%, as recommended by MOURA (1999).

The averages and the frequency of the environmental conditions were calculated in the following categories, considering the values of THI: danger by cold (below 59), lower critical (cold) (59 to 60), lower than recommended (61 to 62), safe (63 to 70), above the recommended (71 to 72), upper critical (heat) (73 to 75), danger by heat (above 75).

According to ALBRIGHT (1990), the enthalpy of humid air is the more useful property in quantifying psychometric processes involving heat exchange. The equation used to calculate the enthalpy was the used by BARBOSA FILHO et al. (2009):

$H = 6.7 + 0.243 * Tbs + \{RH/100 * 10 \wedge [(7{,}5 * Tbs) / (237.3 + Tbs)]\}$ (Eq. 2), where: H = enthalpy (kcal/kg of dry air), Tbs = dry bulb temperature (°C), RH = relative air humidity (%).

As the result of this equation is provided in kcal/kg dry air and value units of the enthalpy Tables is in kJ/kg dry air, the values were multiplied by 4.18.

The data of temperature, relative air humidity and THI were compared by mean tests (Tukey 5%) and analysis of variance.

It was performed the linear regression analysis to assess the correlation between the external environment and the sheds. This analysis sought to evaluate whether the changes suffered by the temperature and humidity of the external environment were accompanied by the change suffered in the internal environment of each of the treatments and what the intensity of this relationship.

It was also compared the times averages for each studied environment and the temperature range in each shed.

RESULTS AND DISCUSSION

Table 1 shows climate data and the thermal comfort indexes found in this study.

TABLE 1. Climate variables average for the treatments and the external environment.

Variables	A	B	Environment
Dry Bulb Temperature (ºC)	27.4 ± 3.3^{a}	24.9 ± 3.3^{b}	20.4 ± 4.4^{c}
Relative Air Humidity (%)	56.4 ± 10.4^{a}	59.3 ± 10.9^{b}	76.4 ± 19.5^{c}
THI	76.0 ± 4.0^{a}	73.0 ± 4.0^{b}	64.0 ± 6.0^{c}
Enthalpy	73.5 ± 5.6^{a}	69.2 ± 5.3^{b}	63.7 ± 6.1^{c}

$^{a.b.c}$ Averages followed by different letters in the same line differ (p>0.05) according to the Tukey's Test.

Regarding to temperature, humidity, enthalpy and THI, all treatments, when compared with each other and with the external environment, were statistically different.

According to the data recommended by the genetics company and the data adopted by SARAIVA et al. (2009), it was considered the ideal temperature range of thermal comfort for this category as 16-24°C. The recommended relative air humidity is between 60-70%, as shown by TOLON et al. (2010). Thus, the only average temperature which was within the comfort zone was the one from the external environment. The best average temperature found was the one of the external environment, followed by B. Thus, according to the room temperature, the shed B provided comfort to animals, having its temperature closer to the outside temperature. Whereas the temperature inside the shed A was 1.4°C above that held with comfort according to the manual of genetics, which considers 26°C of Tbs as the critical limit temperature.

Regarding the relative air humidity, the values inside the sheds A and B were outside the comfort zone, being smaller than the averages of the external environment, which, in turn, was higher than the desired.

The facility B presented its THI average within the range considered as critical, while the facility A was within the range considered as hazardous. Based on this index, the facility B showed better thermal performance than A. To improve the understanding of the behavior of THI during the studied period, it was calculated the frequency with respect to time measurement, in which the THI values were within the conditions: safe (63 to 70), low (61 to 62) or above (71 to 72) the recommended, upper critical (73 to 75) and lower (59 to 60) and cold danger (below 59) and heat (above 75). The results are shown in Table 2.

The external environment was within the safe environment condition (61.6% of the time) in the most of the studied time. In a lower percentage of time it was within the critical heat condition. However, it was the only environment that had data located in the lower critical limit and in danger (cold).

TABLE 2. THI values frequency (%) found in the sheds and external environment.

Environment	**PFrio**	**Cinf**	**AbR**	**Safe**	**AcR**	**Csup**	**PCalor**
Shed A	"-"	"-"	0.1	11.8	5.4	20.3	62.4
Shed B	"-"	"-"	0.5	23.1	18.4	34.9	23.1
External	5.4	3.5	6.1	61.6	11.8	8.4	3.2

PFrio = Cold danger (below 59); Cinf = Lower critical (59 to 60); AbR = Below the recommended (61 to 62); Safe = (63 to 70); AcR = Above the recommended (71 to 72); Csup = Upper critical (73 to 75); PC = Heat danger (above 75).

Facility B could be considered better than A, because it is situated within the safe condition for a longer period of time (23.1% vs. 11.8% of A).

The shed B was situated mostly in an environment with upper critical conditions (34.9%) and the shed A was mostly in an environment of danger by heat (62.4%). So, shed B is considered better than shed A.

The enthalpy is the energy of the humid air per unit of mass of dry air (kJ/kg of dry air).

According to MOURA (1999), the desired for the growth phase, in terms of enthalpy, is from 60.44 to 68.62kJ/kg of dry air. The facility B (69.24kJ/kg of dry air) presented a closer desired value compared to the facility A (73.45kJ/kg of dry air). However, both remained outside the desired range, unlike the external environment (63.68kJ/kg of dry air).

Assessing the frequency in which the enthalpy values were within the desired level, it was observed that the values found in A, B and the external environment were within the comfort zone of the animals at approximately 16, 30 and 54%, respectively. It corroborates with previous data which indicate that the facility B was better than the facility A regarding the comfort.

Figure 2 shows the hourly average temperatures during the studied period, comparing the external environment to A and B.

A linear regression analysis between the external environment and the sheds showed a strong correlation, both for facility A (correlation coefficient = 0.93), and for B (correlation coefficient = 0.95). Although both sheds studied are influenced by the external environment, our results show that the variation of the hourly average for shed A is more like to the variation of the external environment, depending on the slope of the line. Thus, this analysis shows that A is more influenced by the external environment, although both treatments are strongly influenced.

For the analysis of Figure 2, it is clear that average temperatures inside shed A are always higher than those of B.

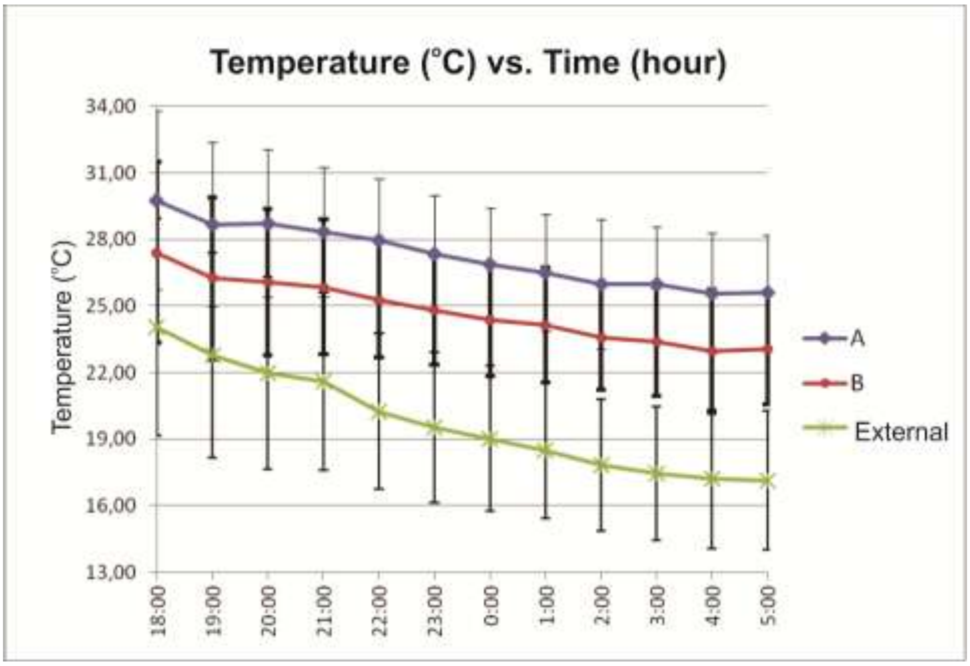

FIGURE 2. Hourly average temperature of the studied treatments and external environmet during all studied period.

Table 3 presents maximum and minimum temperatures and temperature range of each one of the studied environments.

TABLE 3. Maximum (Tmax) and minimum (Tmin) temperatures and temperature range for each one of the studied environments.

Environment	Tmax (ºC)	Tmin (ºC)	Temperature range (ºC)
A	36.5	16.6	19.9
B	34.4	16.4	18.0
External	33.0	10.0	23.0

It can be seen that the highest temperature range was found for the external environment. The temperature range of facilities A and B are similar, although the magnitude of A is greater (19.9°C to 18.0°C), corroborating to the results found in this study, which show greater influence of the external environment in the shed A.

The maximum temperature of A is greater than B (36.5°C to 34.4°C), which means the worst condition for the thermal comfort of animals, though the maximum temperature found in both sheds is above the temperature considered as critical limit of the comfort zone (26°C) according to the manual of genetics.

The minimum temperature found in sheds (16.5 ± 0.1°C) was higher than the minimum temperature in the external environment (10ºC), remaining in the ideal temperature range for thermal comfort (16-24°C) as adopted by SARAIVA et al. (2009). Given these results, it is possible to infer that for cold condition of the external environment, both shed A and B were effective to prevent that the internal temperature drops below the thermal neutral zone.

In view of the data presented in Tables 1, 2 and 3, it is believed that in the studied period it is necessary to use cooling systems for acclimatization during the night and early morning. However, the minimum temperature in the two sheds shows that, if these systems stay on throughout the night and early morning, they may adversely affect the thermal comfort of the animals. Thus, it is suggested that these systems are used, however, with automatic activation.

CONCLUSIONS

Considering the time of night and early morning of the spring under the conditions studied, we concluded that:

Constructively appropriate sheds are important for improving the thermal comfort of growing animals.

Weighting the data of average, maximum and minimum dry bulb temperatures, the THI and the enthalpy found in the period, it is suggested that studies be undertaken to verify the need for activating the air conditioning equipment during the night and early morning.

After analysis of the temperature range in the period, it is still recommended automated control of the acclimatization for the night and dawn.

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