

**ACOUSTIC ENVIRONMENT AND GAS PRODUCTION IN DIFFERENT GROWING-FINISHING SWINE FACILITIES**Doi: <http://dx.doi.org/10.1590/1809-4430-Eng.Agric.v36n6p953-961/2016>**RAFAELLA R. ANDRADE<sup>1\*</sup>, ALESSANDRO T. CAMPOS<sup>2</sup>, DAIANE CECCHIN<sup>2</sup>,  
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**ABSTRACT:** This study aimed to evaluate gas levels and the acoustic environment (noise) of growing-finishing swine in different facilities, one composed of shallow pool (SP) and another of partially slatted floor (PSF). Sensors and a sound level meter were used to measure gas concentrations (CO<sub>2</sub> and NH<sub>3</sub>) and noise at 1.50 meters above the ground and at animal height. Data on gas concentrations and noise levels were measured at 9am, 12pm, and 3 pm. Results showed differences (P<0.05) between noise levels at animal height and gas concentrations measured in relation to stall type and data collection time. The highest noise values were found in the shallow pool stall, measured at animal level. The highest NH<sub>3</sub> (13 ppm) and CO<sub>2</sub> (1174.5 ppm) values were observed in the shallow pool stall at 3pm. The stall floor with shallow pool seems to provide greater welfare in relation to noise level for growing-finishing swine.

**KEYWORDS:** ambience, welfare, air quality, noise.

## INTRODUCTION

Swine farming nowadays uses intensive production in confinement units (GOMES et al., 2014). Intensive farming systems affect the conditions of animal comfort and welfare, and can modify their behavioral patterns, compromising productive and reproductive swine performance (SOUSA et al., 2012).

The search for quality products requires the producer to make changes in the swine production system that prioritize animal welfare and can meet the society's demand, expanding the domestic and foreign markets (BAPTISTA et al., 2011). Animal welfare has been considered extremely important for the animal products sector (CAMERINI & NASCIMENTO, 2012), and for VIEIRA et al. (2010), its absence has a direct impact on food safety.

According to SILVA-MIRANDA et al. (2012), vocalization study and noise level analysis techniques allow to obtain data without animal stress, disruption or manipulation. According to BAPTISTA et al. (2011), sound pressure and vocalization level records stand out as an innovative methodology of behavioral indication.

SAMPAIO et al. (2005) state that swine metabolism may interfere with air quality by releasing heat, moisture and carbon dioxide from breathing, gases from digestion, and dust. In addition, greater air quality control can probably improve productivity levels and present lower animal health risks (PANDORFI et al., 2012).

Ammonia (NH<sub>3</sub>) is an important gas found in swine production facilities, which besides being an irritant to the respiratory system, also affects the health of animals and workers (PAULO et al., 2009).

Various pollutant compounds, such as carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>), are odorless, but have a strong impact on the environment. For this reason, measurements of higher concentrations should be made in order to choose or develop the best way to remove these compounds (HAMON et al., 2012).

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Another inherent factor is the flooring type, which can directly influence gas concentrations and noise levels. WANG et al. (2011), when comparing ammonia concentrations in facilities with partially slatted floor and facilities with overlapping swine bed, in growing and finishing, observed that flooring type influenced ammonia concentrations, and the facility with partially slatted floor showed the highest concentration values.

BANHAZI et al. (2011) evaluated air renewal and carbon dioxide concentration inside swine facilities, and found that CO<sub>2</sub> concentrations are affected by the type of facility.

The main regulations related to qualitative and quantitative noise and gas assessment are: NR-15 (Unhealthy Activities and Operations/Brazilian Decree 3.214/1978 MTE); CIGR (*Commission Internationale du Génie Rural*) and ACGIH (American Conference of Governmental Industrial Hygienists) (SAMPAIO et al., 2005).

Therefore, this study aimed to compare gas levels (NH<sub>3</sub> and CO<sub>2</sub>) and the acoustic environment (noise) of facilities composed of shallow pool and partially slatted floor, in the swine growing and finishing phases.

## MATERIAL AND METHODS

Study conducted in the breeding facilities of a commercial farm of full cycle swine production, located at 21°11'37" south latitude, 45°02'49" west longitude, average altitude of 918 m, in the town of Lavras/MG, from June to September 2014.

The climate, according to the Köppen classification, is *Cwa*, i.e. rainy temperate (mesothermal) with dry winter and rainy summer, subtropical with dry winter (DANTAS et al., 2007).

Growing-finishing commercial swine hybrids were housed in brick sheds covered with tiles of asbestos-cement, supporting structures of reinforced concrete, ceiling height of 3 m, concrete floor and east-west orientation. Each stall consists of two automatic feeders and three nipple type waterers.

Two 64 m<sup>2</sup> stalls with different floor types were compared (Figure 1), one flooring consisted of shallow pool, and the other was partially slatted, each one housing 72 animals.

The shallow pool stall had masonry side locks, and it is characterized by water accumulation in one end, which is about 1 m wide and 10 cm deep. The stall with partially slatted floor has aluminum wire side locks, being typified by two slatted concrete openings over its entire length, with 60 cm wide each.



FIGURE 1. Shallow pool (A); partially slatted floor (B).

A sound level meter (DEC-460 of the Instrutherm brand) was used to assess average noise levels (dB). The instrument has a resolution of 0.1 dB and accuracy of  $\pm 1.5$  dB, operating in compensation scale "A". Noise data collection was performed at three day times (9am, 12pm and 15pm), at the center of each stall.

To measure ammonia (NH<sub>3</sub>) gas concentrations, an electrochemical sensor (Testo<sup>®</sup>, model 316-4) with a resolution of 1 ppm and accuracy of  $\pm 1$  ppm was used, which detects the

instantaneous concentration in a measurement range from 0 to 100 ppm. To collect carbon dioxide (CO<sub>2</sub>) an infrared sensor (Testo<sup>®</sup>, model 535) with a resolution of 1 ppm and accuracy of  $\pm 50$  ppm was used, which detects instantaneous concentration in a measurement range from 0 to 10,000 ppm. Gas concentrations were collected at three different day times (9am, 12pm and 3pm), at the center of each stall.

Given the lack of normality in data distribution (noise at 1.5m and at animal height, NH<sub>3</sub> and CO<sub>2</sub> gas concentration), results were analyzed using non-parametric techniques. To that end, the nonparametric Kruskal-Wallis test with 5% significance was used in the comparison between treatments' medians (shallow pool and partially slatted floor) as done by SILVEIRA et al. (2009) and SARAZ et al. (2014).

In addition, the boxplot graphics composition proceeded, with a confidence interval for the medians (IC = 95%), in order to analyze variation and compare noise and gas concentration values at the different assessment times for each floor type, as done by SILVEIRA et al. (2009). Analyses were conducted with the help of statistical computer program Minitab<sup>®</sup> 16.1.0.

## RESULTS AND DISCUSSION

### Acoustic environment

Noise levels at the worker's height (1.5 m) appears not to differ according to stall type, the same as observed for noise at animal height ( $P > 0.05$ ) (Table 1).

TABLE 1. Median (interquartile range) for noise (dB) at 1.5m from the soil and at animal height in two distinct stall types for growing-finishing swine, with three collection times.

Floor	-----Noise(dB)-----	
	1.5 m	Animal height
Shallow pool	69.15(5.63)a	71.55(5.40)a
Partially slatted	68.60(4.15)a	70.50(3.17)a

Medians followed by same letter in the column do not differ from each other by the Kruskal-Wallis test ( $P > 0.05$ ).

Results for both floor types in both heights assessed did not exceed the level permitted by NR-15 (BRASIL, 1978), which is up to 85 dB, and remained within the regulation at all analyzed times, indicating good health condition for workers.

According to TOLON et al. (2010), because there are no specific regulations to assess animal noise tolerance, the same levels indicated for humans have been adopted as ideal, so the noise levels investigated in this study can also be considered satisfactory from the viewpoint of animal welfare.

The results of this study are corroborated by CASTRO et al. (2013), who assessed the noise in swine maternity pens with masonry partitions or slate rocks. The results observed were also within the limits considered ideal for swine, 85dB.

From the analysis of Figure 2, referring to the noise obtained at 1.5 m above the ground, it is possible to check with the aid of the median confidence interval (CI = 95%), that there is no difference in noise levels within collection times, and there are also no differences for the interaction between treatment and time. It was also verified that, regardless of assessment times, the medians remained below 85 dB, as recommended by NR-15 (BRASIL, 1978).

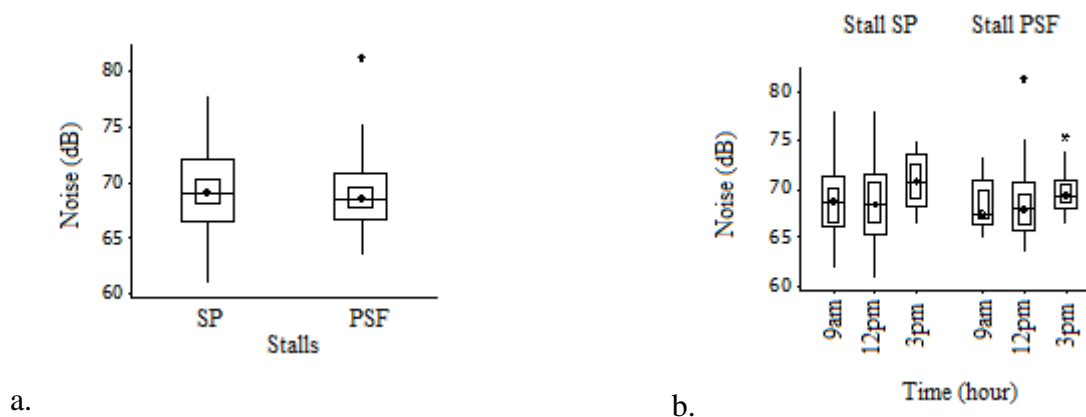


FIGURE 2. Noise boxplot (1.50m from the ground) obtained in two stalls with (a) different typologies, shallow pool (SP) and partially slatted floor (PSF) and (b) by collection time.

There was a difference ( $P < 0.05$ ), however, between typologies within the 3pm collection time (Figure 3) by the medians confidence interval for noise measured at animal height. The stall with partially slatted floor got lower sound pressure levels than the one with shallow pool, with values of 70.95 dB and 73.45 dB, respectively.

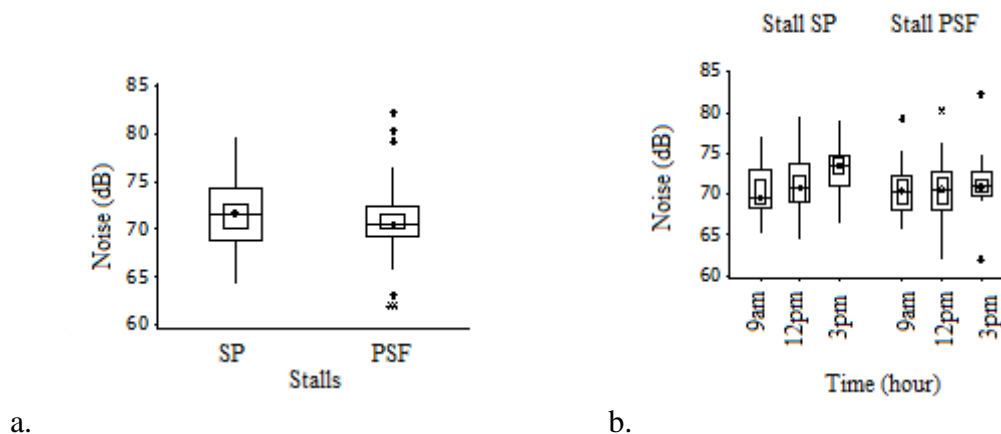


FIGURE 3. Noise boxplot (animal level) obtained in two stalls with (a) different typologies, shallow pool (SP) and partially slatted floor (PSF), and (b) by collection time.

According to SAMPAIO et al. (2005), the intensity of the noise emitted by animals throughout the day may be related to greater swine welfare. Based on this interpretation, the stall with partially slatted floor offers animal comfort and welfare, especially in the afternoon, at 3pm, when lower noise levels were found compared to the facility with shallow pool.

Conversely, however, SILVA-MIRANDA et al. (2012) claim there is a negative correlation between the intensity of the noise produced by piglets and room temperatures, that is, animals under heat stress (temperatures above  $30^{\circ}\text{C}$ ) vocalize with lower intensity compared to those under comfortable conditions. In this case, under this interpretation, it is observed that animals housed on partially slatted floor suffered more discomfort at the 3pm assessment.

This analysis appears to be most appropriate, since according to KIEFER et al. (2010), piglets under heat stress condition change their behavioral patterns, significantly increasing sleeping time. Similarly, BAPTISTA et al. (2011) indicate behavioral inactivity as an evaluation factor for the lack of animal welfare in thermal aspects.

Thus, if animals under heat stress conditions demonstrate typically less active behavior, the noise intensity produced thereby must be lower, whether the noise source is the vocalization of individuals or their activity inside the stalls.

Therefore it can be inferred that swine housed in shallow pool stalls showed higher animal welfare at 3pm compared to those confined in partially slatted floor. This result probably stems from the greater efficiency in animal body heat dissipation on shallow pool, given the possibility of bathing in this kind of system, and as a result increase heat exchanges through evaporation, essential in high air temperature conditions, when sensitive exchanges are less effective.

Through the results of noise analysis at different heights, it can also be considered that the methodology for installing sound level meters at animal height was more efficient in diagnosing animal welfare, since the determination of significant differences between the stalls with different floors was possible only through it.

Regarding NR-15 (BRASIL, 1978), it is noted that regardless of the noise assessment height, time or treatment observed, values remained below what the normative advocates, i.e. below 85 dB.

## Gases

Results for NH<sub>3</sub> and CO<sub>2</sub> air mass concentrations are shown in Table 2. Through the comparison of the treatments' medians, it can be seen that the shallow pool system showed significantly greater concentration than the partially slatted system for both gases ( $P < 0.05$ ).

TABLE 2. Median (interquartile range) for NH<sub>3</sub> and CO<sub>2</sub> concentrations in two distinct stall types for growing-finishing swine, with three collection times.

Floor	-----Gases (ppm)-----	
	NH <sub>3</sub>	CO <sub>2</sub>
Shallow pool	9.00(10.00)a	946.0(497.0)a
Partially slatted	5.00(3.00)b	559.0(233.0)b

Medians followed by same letter in the column do not differ from each other by the Kruskal-Wallis test ( $P > 0.05$ ).

The data on NH<sub>3</sub> gas concentrations per treatment and within the evaluated times are shown in Figure 4. Note that during the times 12pm and 15pm, NH<sub>3</sub> concentration in the shallow pool stall system was higher than for the partially slatted floor ( $P < 0.05$ ).

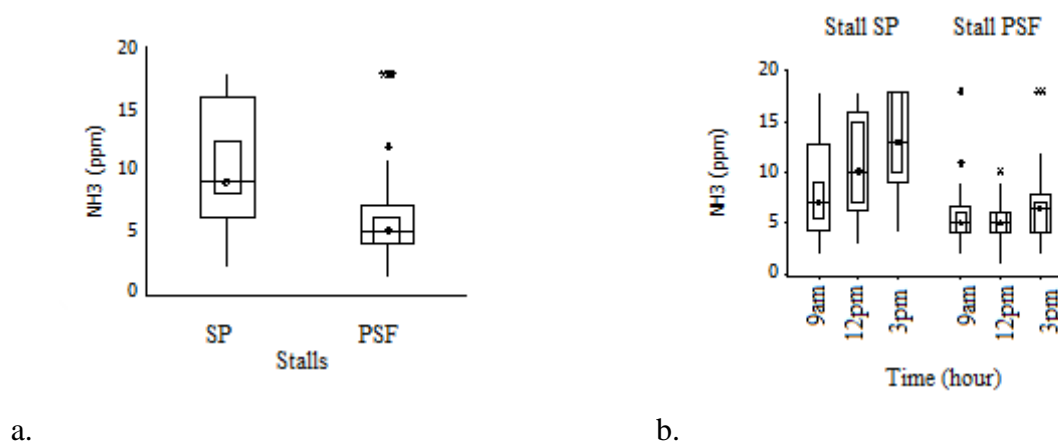


FIGURE 4. Boxplot for NH<sub>3</sub> concentrations obtained in two stalls with (a) different typologies, shallow pool (SP) and partially slatted floor (PSF) and (b) by collection time.

In the comparison between collection times, the highest NH<sub>3</sub> concentrations were 10 ppm and 13 ppm, at 12pm and 3pm, respectively, for the shallow pool stall. AMANCIO et al. (2013), when studying ammonia concentrations in swine maternity in the winter, also found a significant difference due to the different times assessed, with higher means in the last evaluation rounds (1pm and 3pm), indicating that the dynamics of this gas has a strong nictemeral influence.

According to MONTES et al. (2014),  $\text{NH}_3$  is the first product derived from urea decomposition. It is derived from the microbial enzyme urease, which is present in high concentrations in feces and in the environment. Accordingly, ZHOU et al. (2015) show that the highest  $\text{NH}_3$  environmental concentrations are due to increased activity of the enzyme urease, with  $\text{NH}_3$  release peaks occurring two to three hours after urine accumulation.

Thus, higher  $\text{NH}_3$  concentrations in the shallow pool system at 12 pm and 3 pm and in the overall assessment can be explained by the accumulation of excreta, which is characteristic of that system. Conversely, the partially slatted floor allows at least partial waste disposal to the collecting tanks located under the floor, thereby reducing the material exposure time in the environment, and consequently  $\text{NH}_3$  production and emission.

The value of 5.0 ppm for  $\text{NH}_3$  presented in this study for stalls with partially slatted floor was corroborated by FURTADO et al. (2012), who observed a variation between 4.7 and 5.9 ppm for facility in concrete floors, with cleaning management twice a day. Thus, the rapid removal of excreta from indoor stalls and sheds guarantees lower  $\text{NH}_3$  air mass concentrations and benefits the animals housed in terms of comfort and welfare.

$\text{NH}_3$  values found for both systems evaluated are within what is recommended by regulation NR-15 (BRASIL, 1978), which is 20 ppm, and by ACGIH (2001), which sets the maximum tolerance level at 25 ppm (SAMPAIO et al., 2005). However, according to HEBER et al., 2002, the international researchers' recommendation stipulates the tolerance limit at 10 ppm. In this case,  $\text{NH}_3$  concentration exceeds this value at 12 pm and 3 pm for the shallow pool stall.

As seen in Figure 5, there was a difference ( $P < 0.05$ ) for  $\text{CO}_2$ , not only for the treatments' median, but also between treatments at 12 pm and 3pm.

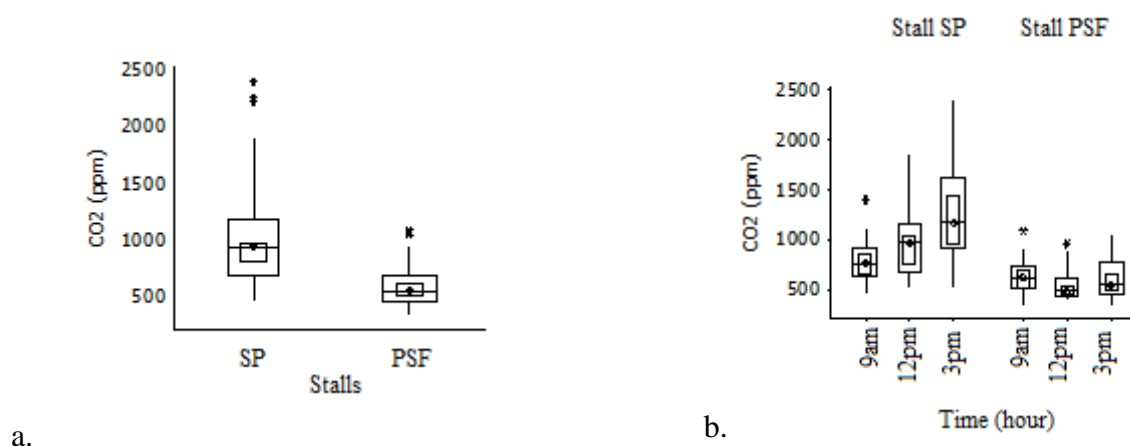


FIGURE 5. Boxplot for  $\text{CO}_2$  concentrations obtained in two stalls with (a) different typologies, shallow pool (SP) and partially slatted floor (PSF) and (b) by collection time.

The highest  $\text{CO}_2$  values found for the shallow pool stall were 974.0 and 1174.5 ppm, at 12pm and 3pm, which were higher than  $\text{CO}_2$  concentrations in partially slatted floor at the same times, with results of 501.0 and 561.5 ppm, respectively. Similarly to  $\text{NH}_3$ ,  $\text{CO}_2$  concentrations for the partially the slatted floor system apparently remained constant throughout the day.

According to PHILIPPE & NICKS (2015),  $\text{CO}_2$  emissions are due primarily to animal metabolism (respiratory rate and body heat production) and to a lesser extent, to the volume coming from waste degradation.

LUZ et al. (2015) state that in heat stress situations animals resort to thermolysis through evaporation; in the case of swine, through increasing respiratory frequency. However, such physiological adjustment can have its efficiency compromised in environments whose relative air

humidity is high, making it difficult to change the water physical state, and reducing heat dissipation which causes respiratory rates to become higher and higher.

From this perspective, the environment with shallow pool favors higher relative air humidity through water accumulation inside the stall and, therefore, being able to promote higher elevations in respiratory rate, theoretically higher than those observed in stalls with partially slatted floor. Another factor that possibly contributed to the result is the accumulation of animal excreta in the shallow pool stall. Unlike the partially slatted floor system, where waste is disposed to the ducts that lead to digestion units, maintenance of feces and urine on the stall surface provides the biological attack and the beginning of the organic matter degradation process by aerobic route, and consequently CO<sub>2</sub> emissions must be higher in these cases.

Even with higher values for the shallow pool system, it appears that concentrations are within what is permitted by regulation NR-15 (BRASIL, 1978), which sets the maximum limit of 3,900 ppm and by ACGIH (2001), which determines the limit of CO<sub>2</sub> occupational exposure at 5000 ppm. Therefore the two types are adequate concerning CO<sub>2</sub> concentration specifications.

SOUSA et al. (2014) evaluated CO<sub>2</sub> concentrations in three treatments in overlapped beds for swine in the finishing phase, and also had results below the concentration level that may cause damage to the animal's health, at all observed times (9am; 11:30am; 2pm and 4:30 pm).

In the same way, CAMPOS et al. (2009), when analyzing CO<sub>2</sub> concentrations in two nurseries with different dimensions, found that both nurseries had not reached levels that could damage the animal's health.

According to CHANG et al. (2001) and as observed in this study, gas concentrations are low in open swine facilities, which are characteristic of tropical regions.

## CONCLUSIONS

Noise levels at the two heights evaluated, both for the shallow pool floor and for partially slatted floor, remained within that permitted by NR-15, therefore both systems are considered salubrious for both workers and animals.

According to noise analysis, there is evidence that the environment with shallow pool system provided better welfare conditions for swine, especially in the afternoon.

CO<sub>2</sub> and NH<sub>3</sub> concentration values were higher for the shallow pool facility when compared to the partially slatted floor, however they both remained within the limits specified in the literature, for both gases.

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